State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
Northern District

Bottle Rock Geothermal Powerplant

Biological Resources Mitigation and Monitoring Biennial Report

April 1988

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Secretary for Resources
The Resources Agency

George Deukmejian
Governor
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FOREWORD

The Bottle Rock Geothermal Powerplant Environmental Impact Report identified the loss of wildlife habitat as an unavoidable impact associated with geothermal development on the Francisco Leasehold. Both direct and indirect habitat losses were identified. Mitigation measures were proposed to offset the loss of wildlife habitat by increasing the wildlife-carrying capacity of the remaining habitat.

Baseline wildlife habitat and population data were collected during the spring of 1981 prior to significant habitat disturbance. Subsequent studies in 1983 and 1985 during powerplant construction and operation identified wildlife population levels and habitat changes since the baseline study. This report compares additional data collected in 1987 to previous data so that the effectiveness of mitigation performed to maintain wildlife populations at or above pre-project levels can be evaluated.

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SUMMARY

This report was prepared to fulfill a portion of the Department's biological resource mitigation and monitoring requirements for the Bottle Rock Geothermal Powerplant. The purpose of this report is to quantify the effectiveness of the wildlife mitigation performed on the leasehold.

Vegetation

Silvicultural measurements of the black oak study area indicated increased density, basal area, and diameter breast height (dbh) for most species since 1981. Black oak remained the dominant tree species with a 62.5 ft^2/acre basal area that comprised approximately 72 percent of the stand basal area. Two young ponderosa pines were killed (possibly porcupine damage), lowering the basal area of this species in the stand and raising the species' average dbh. All silvicultural changes since 1985 are relatively minor and are indicative of the slow pace of forest succession.

Ground cover composition data indicated a reduction (21 percent) in shrub cover since 1981. Shrub species composition indicated an increase in manzanita densities and a reduction in black oak densities (within the shrub layer) since 1981.

Grass species richness has increased 55 percent since 1981.

Forb percent plot occurrence data indicated only minor variation in species presence and occurrence within the black oak study area since 1985. However, forb species richness has increased approximately 51 percent since 1981.

Chaparral ground cover composition data denote a moderate increase in shrub cover and a corresponding decrease in grass cover. Shrub cover remained approximately 14 percent less than the 1981 level due to the 1982 controlled burn. Chamise, manzanita, live oaks, and poison oak were found at greater densities in 1987 than in 1981.

The number of grass species present within the chaparral study area decreased by 25 percent since 1981.

The number of chaparral forb species decreased approximately 18 percent since 1985 but remained 44 percent greater than in 1981. Forb occurrence was greater in the burned portion than in the unburned portion of the chaparral study area.

Amphibians and Reptiles

Three amphibian and nine reptile species were identified on the leasehold during 1987. California newt was the only amphibian species observed previously which was not identified during 1987.

Striped racers were observed on the leasehold for the first time in 1987. Common and western terrestrial garter snakes were not identified during 1987. All other previously identified reptile species were present during 1987. Amphibian and reptile species richness is being maintained on the leasehold.

Birds

Ninety-six avian species have been observed on the Francisco Leasehold during the four wildlife studies (1981, 1983, 1985, and 1987).

Eighty-two species have been observed within the black oak study area during the four wildlife studies. Sixty species were found within the black oak study area in 1987, an increase of five species since 1981. Diversity and equitability are virtually identical to those found in 1981, but total density increased 2.46 birds/acre since 1981. Brewer's blackbird was the only species considered dominant in both 1981 and 1987.

Within the chaparral study area, 50 species were identified in 1987, representing an increase of 13 species since 1981. Total density increased 78 percent since 1981. Diversity remained relatively stable since 1981, while equitability decreased moderately. Dominant chaparral species in 1987 included Bewick's wren, lesser goldfinch, rufous-sided towhee, scrub jay, and wrentit.

Nest box utilization increased to 74 percent in 1985, but declined to 40 percent in 1987. Seven secondary cavity nesting species have utilized the nest boxes since their installation in 1982. The density of secondary cavity nesting species was approximately 360 percent higher in 1987 than in 1981 in the area containing nest boxes. Except for western bluebirds, all secondary cavity nesting species' use of nest boxes declined from 1985 to 1987.

The 1982 five-acre chaparral burn increased both structural and plant species diversity, which are two important factors in bird species diversity and abundance. Total density and diversity of birds (as defined by a diversity index) peaked three to four years following the burn. Species richness continues to increase.

Mitigation measures have proven successful in maintaining species diversity and density of the leasehold avifauna.

Mourning Doves

Mourning dove densities on the leasehold in 1987 represent a 14 percent decrease since 1981. Mourning dove densities are ten times greater in the burned portion of the chaparral study area than within the unburned area. No dove nest cones have been utilized by any species since their installation. Dove cones are of dubious value.

Small Mammals

Twelve small mammal species were present during 1987, compared to 13 in 1981. Brush mice were captured for the first time in 1987. However, no chickaree, California ground squirrel, western harvest mice, or Trowbridge shrew were captured or observed.

Small mammal trapping within the meadow-edge trap unit indicated a four-fold increase in pinyon mice since 1981. No deer mice, western harvest mice, Sonoma chipmunk, or brush rabbit were captured in this trap unit in 1987.

Pinyon mice and deer mice captures declined 28 percent and 70 percent, respectively, within the heavy understory-black oak woodland trap unit since 1981. Woodrat captures doubled since 1983 (none were captured in 1981). No western harvest mice, California voles, or Trowbridge shrews were captured in 1987 within this trap unit.

Trapping in the light understory-black oak trap unit yielded 76 and 34 percent reductions in pinyon and deer mouse captures, respectively, since 1981.

Total small mammal captures declined 75 percent since 1981 in the low chamise chaparral trap unit. A 91 percent reduction in the capture of woodrats since 1981 contributed to the large decrease in total small mammal captures in this unit.

The old-growth mixed chaparral trap unit was subject to a controlled burn in 1982. Small mammal populations decreased significantly following the burn. Populations of deer mice, pinyon mice, and dusky-footed woodrats decreased since the burn, while brush mice, brush rabbits, California voles, and kangaroo rats have increased.

Gray Squirrels

Time/area counts, catch/unit effort, and capture data all indicate a 57-60 percent decline in the small gray squirrel population within the black oak study area since 1981. Since their installation in 1982, an average of one squirrel box/year has been utilized by nesting gray squirrels. Twelve young have been reared in the boxes. Average litter size is 2.0 squirrels/litter and average annual production (nest boxes only) is 0.14 squirrels/acre. American kestrels and screech owls also utilized gray squirrel nest boxes in 1987.

Mammalian Carnivores

Three species of mammalian carnivores were found on the Francisco Leasehold during both 1985 and 1987, compared to six species in 1981. No spotted skunk or gray fox have been detected since 1981. No mitigation measures were employed to increase mammalian carnivore populations. Mitigation measures employed to enhance prey populations appear to have little positive influence on the species richness of mammalian carnivores.

Black-Tailed Deer

Deer use within both study areas declined sharply from 1981 to 1983, but has remained relatively stable since 1983. Black oak deer use has declined approximately 60 percent since the first four quarterly counts (October 1981 through July 1982). Chaparral deer use has declined 56 percent during the same period.

Within the black oak study area, browse, seedling, and young age classes exceed decadent classes by more than 5 percent in 1987, indicating range quality is good. Browse availability was rated poor (worse in 1987 than in previous years). The browse quality trend has remained good (1981-1987), while browse availability was rated good in 1981 but poor in 1987.

Within the chaparral study area, both range quality and browse availability were rated good in 1987, as they were in 1981. The 1982 5-acre controlled burn within the chaparral study area has not maintained deer populations at preproject levels.

INTRODUCTION

The Department of Water Resources (DWR) is required (DWR 1979) to mitigate the adverse impacts to wildlife populations associated with construction and operation of the Bottle Rock Geothermal Powerplant. Requirements of the California Energy Commission (CEC) also include monitoring of wildlife populations to determine the effectiveness of the wildlife mitigation measures. A baseline wildlife population study was conducted during April and May of 1981 prior to mitigation and significant habitat disturbance on the leasehold (DWR 1981). Subsequent wildlife population monitoring has occurred biennially since 1981. Comparison of the results of these wildlife population studies allows evaluation of the effectiveness of mitigation measures employed to maintain wildlife species richness during construction and operation of the Bottle Rock Geothermal Powerplant. This study is part of the Department's long-term monitoring program for the project and was designed in cooperation with the CEC, the Department of Fish and Game, and Dr. Philip Leitner, a biological resources consultant.

The Francisco Leasehold is located in Sections 5 and 6, Township 11 North, Range 3 West, Mount Diablo Base and Meridian (Figure 1). The leasehold covers approximately 370 acres in a rural mountainous portion of the north-central coast range.

Climate of the study area consists of hot, dry summers and cool, wet winters. Precipitation is seasonal from November to June and averages 52 inches/year. Winter precipitation often occurs in the form of snow, but it seldom remains on the ground for more than a few days.

The physical topography of the study area is that of relatively steep, rugged, mountainous terrain ranging in elevation from 2,500 to 3,500 feet.

Two 25-acre study areas were selected and each subdivided into forty 165-by-165-foot plots (Figure 2). One study area is comprised of mixed chaparral habitat, and the other of black oak habitat. All data on vegetation, amphibians, reptiles, birds, small mammals, gray squirrels, mammalian carnivores, and black-tailed deer, unless otherwise specified, were collected within the study plots. Each plot center is marked with a 1.3-inch by 5.6-foot steel fence post and identified with a numbered aluminum tag. All field work was conducted between April 1 and June 6 during each study (1981, 1983, 1985, and 1987), except quarterly deer pellet group counts and annual nest structure monitoring.

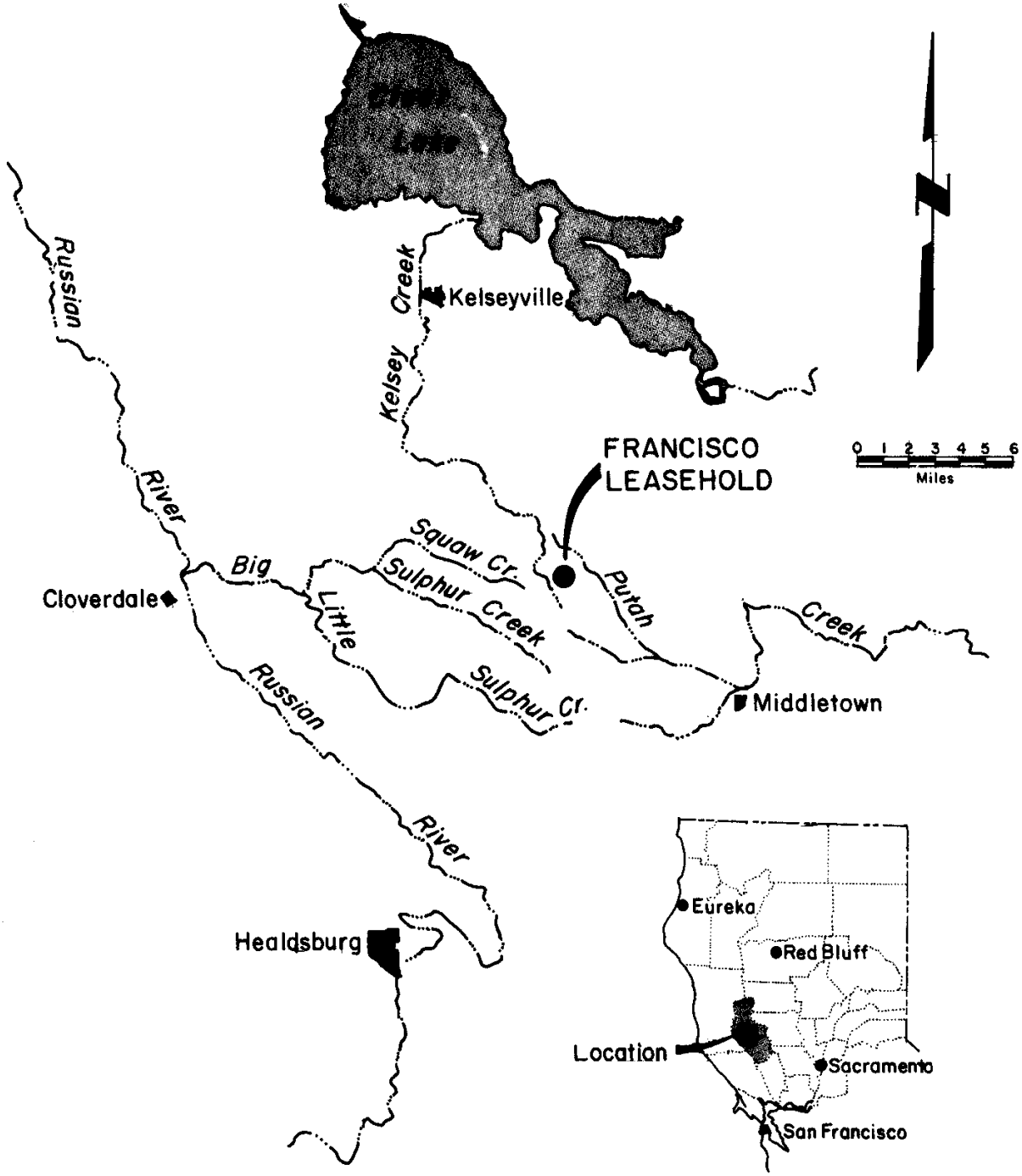

Figure 1. Location of the Francisco Leasehold.

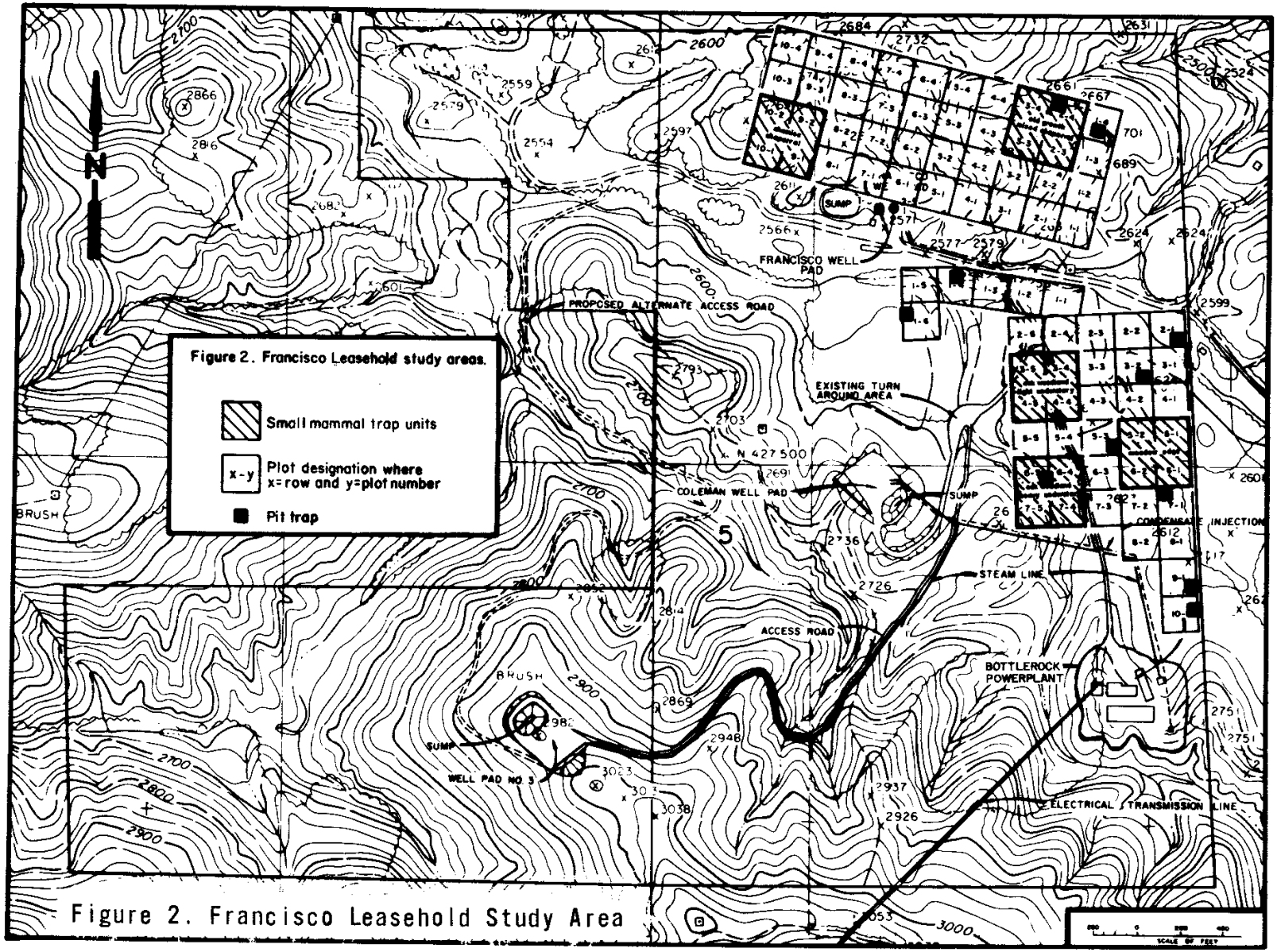

Figure 2. Francisco Leasehold Study Area

Mitigation Measures

Mitigation measures were employed to compensate for unavoidable wildlife habitat losses during construction and operation of the Bottle Rock Geothermal Powerplant. The required mitigation included controlled burning, installation of nest structures, and water development (quail guzzler) (DWR 1979).

Fifty each of dove nest cones, bird nest boxes, and gray squirrel nest boxes were installed in the black oak habitat during February 1982 (Figure 3). The dove cones were distributed among all 40 black oak study plots at heights ranging from 6 to 16 feet. The proportion of cones placed in a species of tree corresponds closely to the percent occurrence of that species in the study area. Forty songbird nest boxes were installed in 20 plots within the black oak study area. The other 20 plots in the black oak study area were left without boxes to serve as a control for evaluating the effectiveness of the bird boxes in maintaining the populations of secondary cavity nesting birds. The other ten bird boxes were installed elsewhere on the leasehold. Control and test areas were similarly established for the gray squirrel nest boxes in the black oak study area. The ten remaining squirrel boxes were installed in suitable habitat near the Coleman Well pad.

Approximately five acres of mixed chamise chaparral were manipulated with a controlled burn during May 1982 (Figure 3). The burning of old-growth mixed chaparral was intended to increase forage production and nutritional value for deer on the leasehold.

Two 750-gallon quail guzzlers were installed in 1982 to provide water through the dry season for quail and other wildlife.

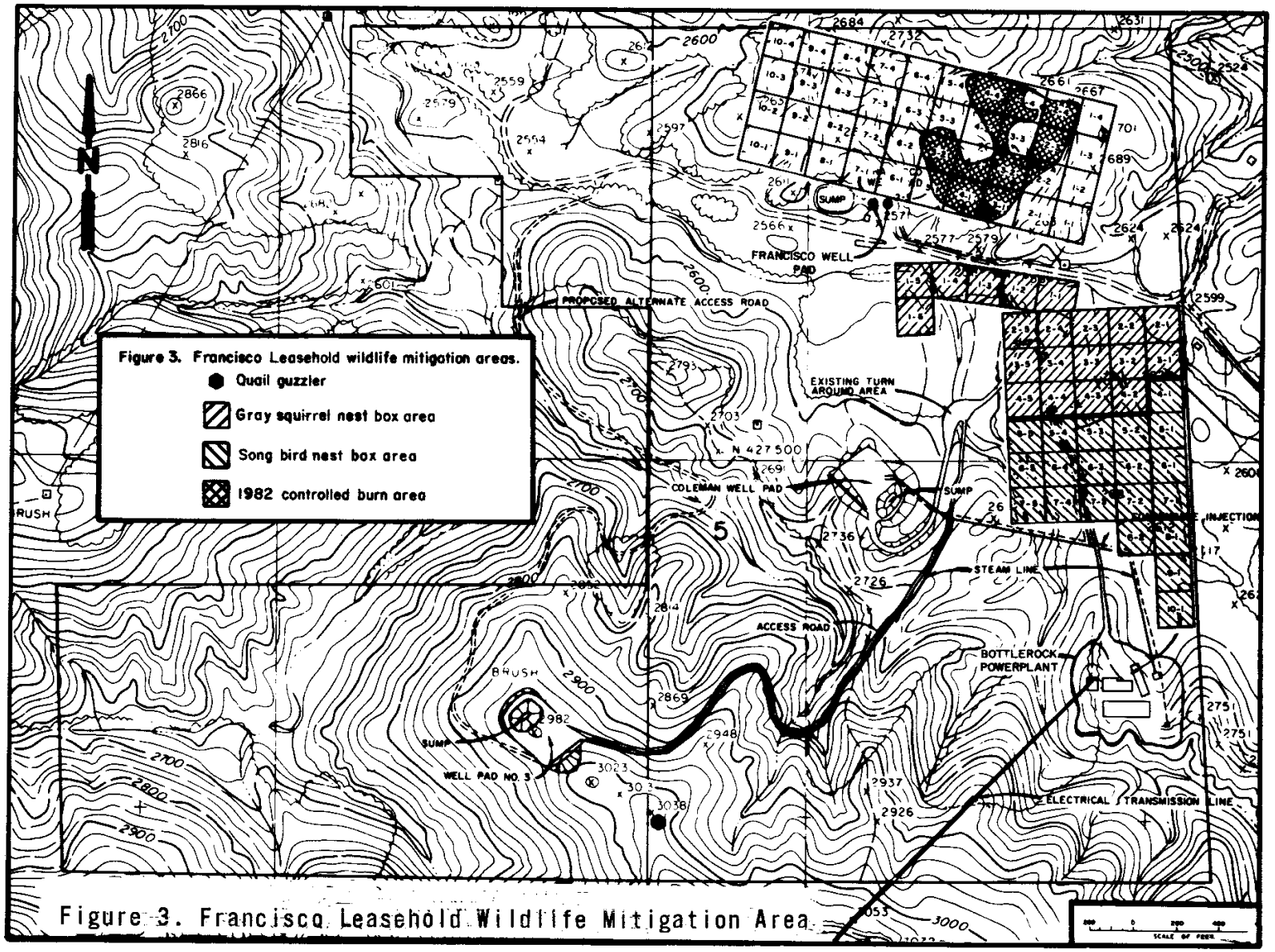

Figure 3. Francisco Leasehold Wildlife Mitigation Area

VEGETATION

Introduction

Vegetative data were collected to monitor changes in the wildlife habitats over time. Where applicable, vegetative data are included in the discussion of wildlife population trends.

Methods

Silvicultural parameters were measured during April in 1981, 1983, 1985, and 1987. Silvicultural data collected included stand species composition, basal area, and diameter at breast height (dbh). A 20-power prism held over each plot center delineated individual trees within each 0.6-acre plot.

Around each of the 80 plot centers, a circular 43.6 ft^2 (milliacre) plot was established and data recorded on percent ground cover, including bare soil, erosion pavement, rock over 3 inches in diameter, litter, grasses, forbs, and shrubs. The shrub cover was further subdivided by recording each shrub into an age and a form class. These data allow the assessment of range and forage availability trends which are presented in the black-tailed deer section of this report. All grass and forb species which occurred within 12 inches of each plot center were identified and recorded. It was necessary to revisit each of the plots biweekly to identify grass and forb species due to phenologic changes. All grasses and forbs not previously identified (DWR 1981,1984) were keyed, using Abrams (1951), Munz and Keck (1973), and Neilson (1981).

Results and Discussion

Species lists containing all vegetative species identified on the leasehold are presented in Appendices A-1 and A-2. These lists, as well as the herbarium collection, were updated as new species were identified.

Black Oak Study Area

Black oak (*Quercus kelloggii*) remained the dominant tree species with an average of 62.5 ft^2/acre basal area compromising 72 percent of the stand basal area (Table 1). Black oak basal area ranged from 0 ft^2/acre to 240 ft^2/acre. Ponderosa pine (*Pinus ponderosa*) comprised 18 percent of the stand basal area (15.8 ft^2/acre). Two young ponderosa pines were lost since

Table 1. Silvicultural measurements for the black oak habitat.

		Variable Plot Data							
		Number of Individuals	Percent Plot Occurrence[1/]	Basal Area			Diameter Breast Height		Percent Plot Occurrence[2/]
	Year			ft^2/acre	Range	Percent of Total	x	Range	
Black oak (*Quercus kelloggii*)	1981	105	76.3	57.8	0-217	73.1	15.4	1.2-55.1	100
	1983	121	75.0	60.1	0-240	72.0	17.0	2.2-50.9	100
	1985	124	80.0	62.5	0-240	72.3	16.7	1.9-49.0	100
	1987	122	80.0	62.5	0-240	71.5	17.1	2.2-50-3	100
Ponderosa pine (*Pinus ponderosa*)	1981	28	35.0	13.9	0-100	17.6	24.4	5.1-38.2	65.7
	1983	34	37.5	16.9	0-100	20.2	24.9	6.0-44.6	95.0
	1985	33	37.5	16.5	0-100	19.1	24.6	6.4-39.2	92.5
	1987	31	37.5	15.8	0-100	18.1	26.8	7.0-39.4	95.0
Locust (*Robinia pseudo-acacia*)	1981	4	2.6	2.2	0- 78	2.8	17.7	3.1-29.5	5.2
	1983	3	2.5	1.3	0- 60	1.6	17.0	10.9-27.7	2.5
	1985	3	2.5	1.5	0- 60	1.7	15.2	10.2-18.1	2.5
	1987	5	2.5	2.5	0-100	2.9	23.8	10.3-31.7	2.5
Madrone (*Arbutus menziesii*)	1981	4	2.6	2.2	0- 78	2.8	6.2	3.9- 7.9	39.4
	1983	4	2.5	2.2	0- 80	2.6	7.6	3.8-10.5	55.0
	1985	5	2.5	2.5	0-100	2.9	6.8	4.1- 9.2	62.5
	1987	6	2.5	3.0	0-120	3.4	7.4	3.8- 9.6	65.0
Douglas fir (*Pseudotsuga menziesii*)	1981	5	12.5	3.0	0- 21	3.8	29.6	20.9-37.0	55.2
	1983	6	15.0	3.0	0- 20	3.6	27.0	21.8-32.8	77.5
	1985	7	17.5	3.5	0- 20	4.0	28.1	22.9-33.7	75.0
	1987	7	17.5	3.5	0- 20	4.0	28.7	23.2-34.4	80.0
Sugar pine (*Pinus lambertiana*)	1981	-	-	-	-	-	-	-	7.8
	1983	-	-	-	-	-	-	-	2.5
	1985	-	-	-	-	-	-	-	10.0
	1987	-	-	-	-	-	-	-	7.5

Table 1 (cont'd.)

		Variable Plot Data							
		Number of Individuals	Percent Plot Occurrence[1/]	Basal Area			Diameter Breast Height		Percent Plot Occurrence[2/]
	Year			ft^2/acre	Range	Percent of Total	x	Range	
Interior live oak (*Quercus wislizenii*)	1981	-	-	-	-	-	-	-	5.2
	1983	-	-	-	-	-	-	-	7.5
	1985	-	-	-	-	-	-	-	10.0
	1987	-	-	-	-	-	-	-	12.5
Oregon ash (*Fraxinus latifolia*)	1981	-	-	-	-	-	-	-	5.2
	1983	-	-	-	-	-	-	-	2.5
	1985	-	-	-	-	-	-	-	2.5
	1987	-	-	-	-	-	-	-	2.5
Digger pine (*Pinus sabiniana*)	1981	-	-	-	-	-	-	-	5.2
	1983	-	-	-	-	-	-	-	7.5
	1985	-	-	-	-	-	-	-	17.5
	1987	-	-	-	-	-	-	-	17.5
Willow (*Salix* sp.)	1981	-	-	-	-	-	-	-	-
	1983	-	-	-	-	-	-	-	-
	1985	-	-	-	-	-	-	-	2.5
	1987	-	-	-	-	-	-	-	2.5

1/ Determined with a prism.

2/ Actual occurrence of plants in a 165-foot x 165-foot area.

1985 (possibly porcupine damage), slightly reducing the basal area within the stand. Average dbh increased almost 2 inches with the loss of the two young ponderosa pines. Black locust (Robinia pseudo-acacia) showed an increase in basal area, percentage of the stand composition, and average dbh since 1981. Douglas fir (Pseudotsuga menziesii) and madrone (Arbutus menziesii) data have changed little since 1981. All silvicultural changes since 1981 are minor and are indicative of the slow pace of forest succession.

Ground cover composition (Figure 4) data indicate a trend towards reduced shrub cover, which has decreased approximately 21 percent since 1981. Canopy closure associated with overstory maturation leads to the gradual elimination of shade-intolerant ground cover. Increased ground cover composition of litter is related to plant phenology (i.e., the survey was conducted before grass and forb seasonal growth had begun).

Shrub species composition and density analysis (Figure 5) indicate an increase in the density of manzanita (Arctostaphylos spp.) since 1981 and a decrease in the density of black oak within the shrub layer during the same time period. Both changes are artifacts of the techniques used to develop shrub species composition and density data. Lateral growth by mature manzanitas allows individual plants rooted outside the perimeter of the milliacre plot to extend within the plot where they are tallied. This serves to increase the density of manzanita within the black oak study area. A more practical technique would have been to include in the data only those individuals rooted within the milliacre plot. However, if only those individuals rooted within the milliacre plot are included in the data, it is possible to have 100 percent shrub cover on a plot and have no shrubs rooted within the plot. Tradeoffs exist with either variation of the technique. Black oak occurrence within the shrub layer (i.e., live limbs within 4 feet of the ground) decreased substantially since 1983 due to shading by the overstory. This serves to lower the number of black oaks classified as shrubs, which in turn lowers the amount of ground cover classified as shrub cover.

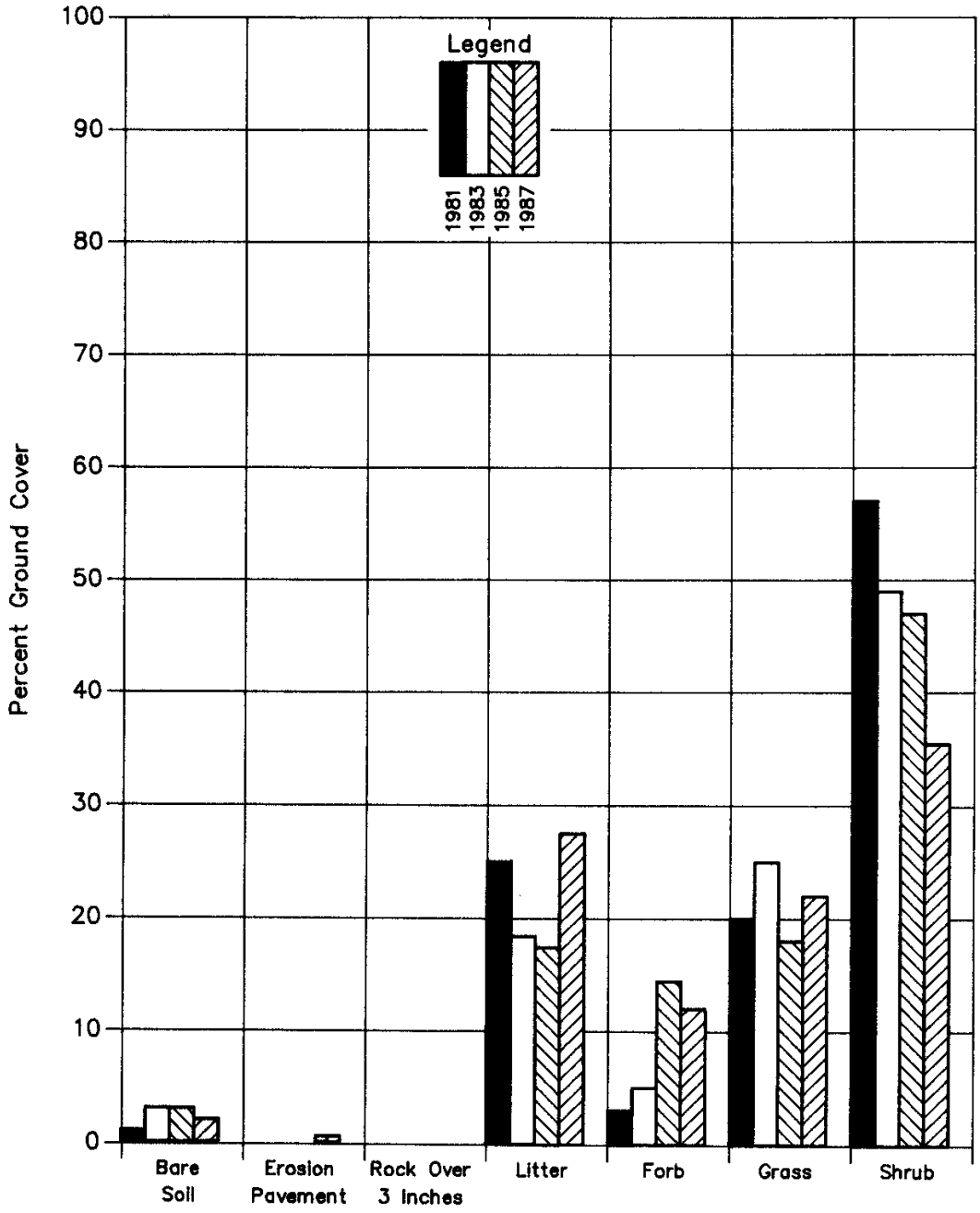

Figure 4. Mean percent of ground cover, excluding canopy, from the milliacre plots in the black oak study area.

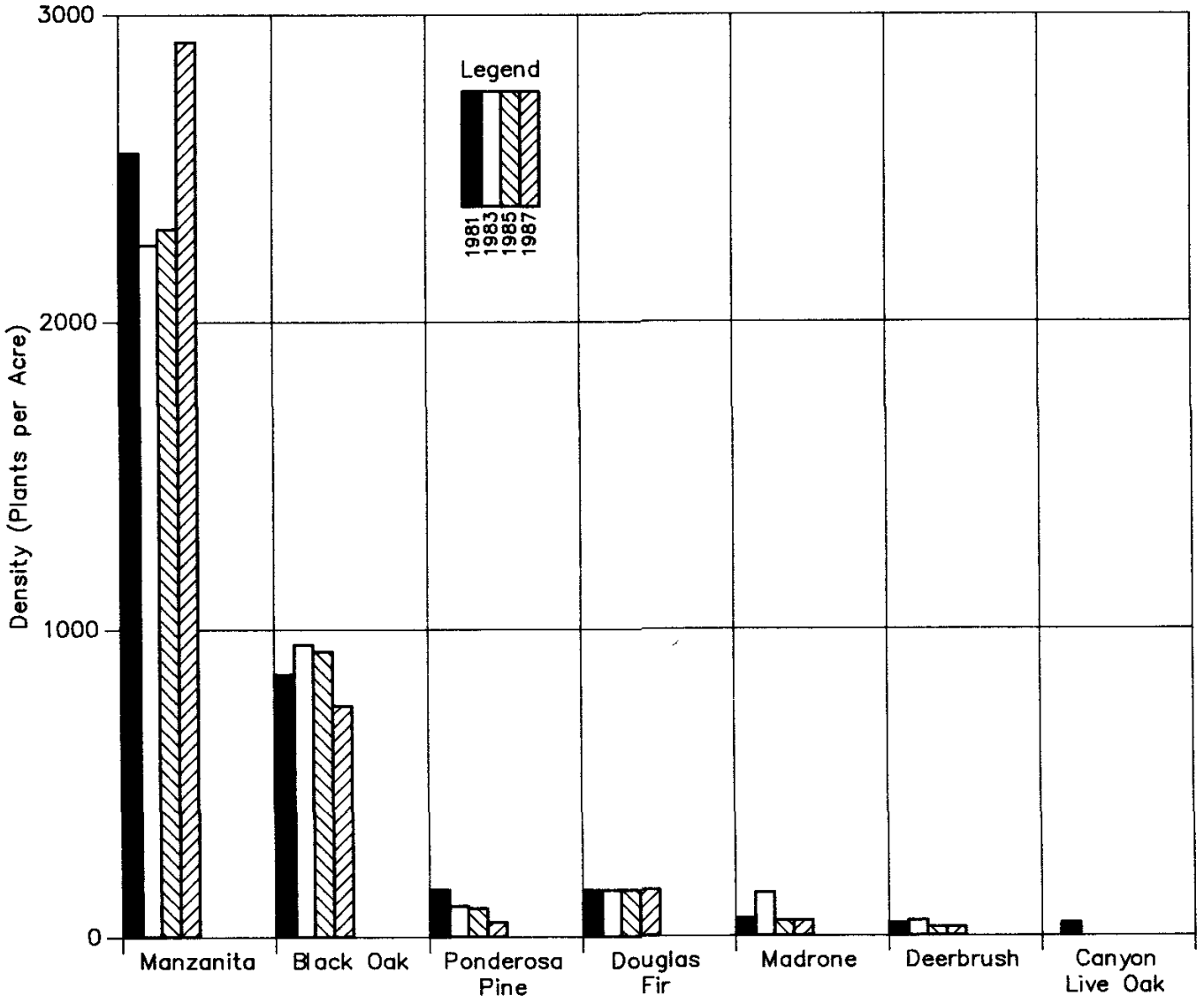

Figure 5. Shrub species composition of the black oak study area.

Fourteen grass species were present during 1987 (Table 2). This represents an increase of five species since 1981 and a slight decrease (two species) since 1985. Percent plot occurrence of grass species was similar in 1985 and 1987 for most species except medusa-head (Taeniatherum sp.), which occurred in over 32 percent of the plots during 1985. Medusa-head was present on only 2.5 percent of the plots in 1987. Medusa-head is a weedy introduced annual which rarely grows in shade, moist soil, or areas receiving over 50 inches of precipitation per year. This species is extremely hardy, as unsuccessful statewide eradication attempts have proven. The reasons behind the reduction in occurrence of this species are unknown.

Table 2. Percent occurrence of grasses within a 12-inch radius of each plot center in the black oak study area.

	1981	1983	1985	1987
Aira caryophyllea	12.5	12.5	15.0	15.0
Anthoxanthum odoratum	22.5	27.5	40.0	45.0
Briza maxima	-	5.0	-	-
Briza minor	5.0	2.5	2.5	2.5
Bromus sp.	27.5	37.5	35.0	35.0
Bromus mollis	22.5	27.5	35.0	32.5
Bromus rubens	-	10.0	5.0	7.5
Cynosurus sp.	-	2.5	2.5	2.5
Datylis glomerata	-	-	2.5	2.5
Elymus glaucus	-	-	25.0	17.5
Festuca rubra	-	12.5	2.5	-
Hordeum sp.	-	-	5.0	-
Lolium perenne	-	-	5.0	7.5
Melica sp.	-	2.5	5.0	10.0
Poa pratensis	-	-	2.5	7.5
Stipa sp.	5.0	-	-	-
Taeniatherum sp.	5.0	12.5	32.5	2.5
Vulpia sp.	5.0	12.5	32.5	25.0
Unidentified bunchgrass	5.0	-	-	-

The number of forb species present within the black oak study area decreased slightly in 1987 (Table 3). Thirty-seven species were identified in 1981, 48 in 1983, 58 in 1983, and 56 in 1987. Five species not previously inventoried within the black oak study area were present in 1987. These species are mouse-eared chickweed (Cerastium visrosum), short-podded hosackia (Lotus humistratus), clover (Trifolium hirtum), Indian paint brush (Castilleja sp.), and purple sanicle (Sanicula bipinnatifida). Only mouse-eared chickweed had not previously been identified on the leasehold. Common rush (Lazula sp.) and small-flowered hosackia (Lotus micranthus) both exhibited large increases in occurrence since 1985.

Dominant forb species (i.e., over 33 percent plot occurrence) remained the same as in 1985. Dominant forb species include bowl-tubed iris (Iris macrosiphon), California vetch (Vicia californicus), western buttercup (Ranunculus occidentalis), and blue field madder (Sherardia arvensis). Dominant forbs in 1981 also included bowl-tubed iris, California vetch, and blue field madder, as well as American vetch (Vicia americana). Forb percent plot occurrence data indicate only minor changes in the species occurrence since 1985.

Chaparral Study Area

Chaparral ground cover composition in 1987 was characterized by moderate increases in shrub cover and moderate decreases in grass cover (Figure 6). All other ground cover categories remained within 1 percent of their 1985 value. Shrub cover has increased annually following the 1982 controlled burning of 5 acres within the chaparral study area (Table 4). Shrub regrowth (indicating plant succession) has decreased the amount of grass cover. Shrub cover remained 14 percent less than pre-burn (1981) levels for the chaparral study area as a whole and 46 percent less than pre-burn levels in the burn unit. Comparison of ground cover composition on the burned area documents the succession toward the pre-burn composition.

Chaparral shrub density (Figure 7) indicated increased densities of chamise (Adenostoma fasiculatum), manzanitas, and live oaks (Quercus spp.) since 1981. Poison oak (Toxicodendron diversilobum) density decreased primarily due to intra-specific competition among sprouts on one plot. Ponderosa pine was inventoried among the shrub layer in 1987 for the first time.

Table 3. Percent occurrence of forbs within a 12-inch radius of each plot center in the black oak study area.

		1981	1983	1985	1987
Amaryllidaceae	Brodiaea pulchella	-	2.5	2.5	-
Boraginaceae	Cynoglossum grande	7.5	7.5	2.5	5.0
	Pectocarya pusilla	-	-	2.5	-
	Plagiobothrys sp.	-	5.0	10.0	5.0
	Cerastium viscosum	-	-	-	5.0
Caryophyllaceae	Kohlrauschia velutina	2.5	-	-	-
	Silene gallica	-	2.5	2.5	-
	Stellaria media	-	-	5.0	2.5
Compositae	Achillea borealis	7.5	7.5	10.0	7.5
	Agoseris heterophylla	2.5	2.5	-	-
	Carduus pycnocephalus	-	2.5	2.5	2.5
	Hieracium albiflorum	-	-	2.5	2.5
	Hypochoeris glabra	-	2.5	10.0	10.0
	Lasthenia chrysostoma	2.5	2.5	2.5	5.0
	Madia sp.	5.0	2.5	-	-
	Madia minima	-	2.5	10.0	15.0
	Micropus californicus	-	-	2.5	2.5
	Senecio aronicoides	-	-	2.5	-
	Taraxacum sp.	-	2.5	2.5	2.5
	Wyethia angustifolia	15.0	12.5	12.5	2.5
Convolvulaceae	Convolvulus subacaulis	12.5	12.5	12.5	15.0
Cruciferae	Draba verna	-	-	2.5	5.0
	Thysanocarpus curvipes	-	-	2.5	2.5
Geraniaceae	Geranium dissectum	2.5	-	-	5.0
	Geranium molle	5.0	15.0	7.5	-
	Erodium botrys	2.5	-	-	2.5
Hydrophyllaceae	Nemophila menziesii	-	-	2.5	-
	Nemophila parviflora	5.0	-	-	-
Iridaceae	Iris macrosiphon	35.0	45.0	40.0	40.0
Juncaceae	Lazula sp.	10.0	27.5	2.5	25.0
Labiatae	Mentha pulegium	10.0	7.5	5.0	10.0
	Monardella sp.	2.5	10.0	2.5	5.0
	Stachys rigida	2.5	5.0	5.0	5.0
Leguminosae	Lotus corniculatus	-	2.5	-	2.5
	Lotus humistratus	-	-	-	5.0
	Lotus micranthus	-	-	2.5	17.5
	Lupinus bicolor	7.5	7.5	2.5	5.0
	Lupinus formosus	7.5	10.0	7.5	10.0
	Lupinus latifolius	17.5	17.5	17.5	5.0
	Trifolium sp.	5.0	-	-	-
	Trifolium bifidum	-	10.0	12.5	7.5
	Trifolium gracilentum	2.5	-	-	-
	Trifolium hirtum	-	-	-	5.0
	Trifolium microcephalum	-	5.0	10.0	5.0
	Trifolium microdon	-	-	5.0	2.5
	Vicia americana	40.0	22.5	25.0	30.0
	Vicia californicus	67.5	57.5	57.5	55.0

Table 3 (cont'd.)

		1981	1983	1985	1987
Liliaceae	Calochortus amabilis	-	-	5.0	7.5
	Calochortus nudus	2.5	2.5	2.5	2.5
Onagraceae	Clarkia gracilis	-	-	2.5	-
Polemoniaceae	Collomia heterophylla	-	2.5	7.5	2.5
	Linanthus bicolor	-	2.5	2.5	-
	Microsteris gracilis	-	-	15.0	12.5
Polygonaceae	Rumex sp.	-	2.5	2.5	2.5
Portulacaceae	Montia gypsophiloides	-	2.5	2.5	-
Primulaceae	Dodecatheon hendersonii	5.0	2.5	7.5	2.5
Pteridaceae	Pteridium aquilinum	2.5	7.5	-	2.5
Ranunculaceae	Ranunculus occidentalis	30.0	45.0	35.0	42.5
Rubiaceae	Galium aparine	10.0	10.0	10.0	7.5
	Sherardia arvensis	62.5	55.0	50.0	62.5
	Castilleja sp.	-	-	-	2.5
Scrophulariaceae	Collinsia grandiflora	2.5	2.5	2.5	-
	Collinsia parviflora	-	5.0	-	-
	Orthocarpus lithospermoides	-	2.5	-	-
	Pedicularis densiflora	2.5	2.5	2.5	2.5
	Penstemon heterophyllus	2.5	-	-	-
Sellaginellaceae	Selaginella hanseni	-	-	5.0	5.0
Umbelliferae	Apiastrum angustifolium	2.5	2.5	2.5	2.5
	Osmorhiza chilensis	7.5	2.5	10.0	20.0
	Sanicula bipinnatifida	-	-	-	2.5
	Sanicula crassicaulis	-	5.0	10.0	12.5
	Scandix pecten-veneris	-	-	2.5	-
	Torilis nodosa	-	-	30.0	17.5
Valerianaceae	Plectritis sp.	-	2.5	2.5	2.5
Violaceae	Viola lobata	2.5	2.5	2.5	2.5
	Viola pedunculata	2.5	2.5	5.0	5.0

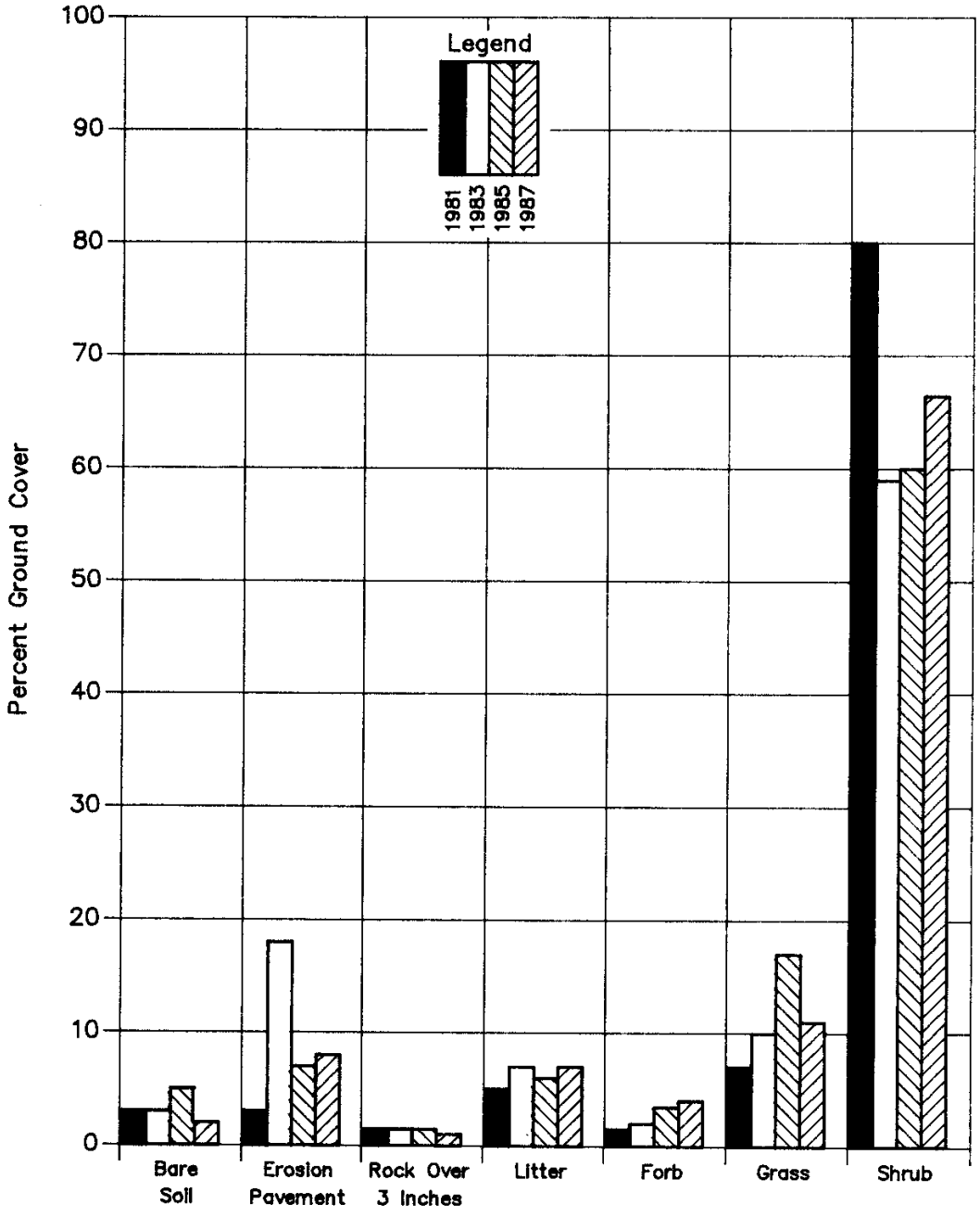

Figure 6. Mean percent ground cover, excluding canopy, from the milliacre plots in the chaparral study area.

Table 4. Comparison of ground cover compositions within burned chaparral plots in 1981, 1983, 1985, and 1987.

Ground Cover	1981 *	1983	1985	1987
Bare soil	1.4	8.6	5.4	3.3
Erosion pavement	1.4	45.0	13.1	15.0
Rock over 3 inches	0.0	3.2	2.7	1.8
Litter	4.5	9.6	5.6	12.3
Forb	0.0	2.7	6.3	4.1
Grass	3.2	2.3	33.1	20.9
Shrub cover	89.5	28.2	33.1	43.2

* 1982 burn

The number of chaparral grass species decreased since 1981 (Table 5). Eight species were recorded in 1981, six in 1983, eight in 1985, and six in 1987. The majority of grass species exhibited reductions in occurrence during 1987. Silvery hair grass (Aira caryophyllea), ripcut grass (Bromus diandrus), soft cheat (Bromus mollis), downy brome grass (Bromus tectorum), nitgrass (Gastridium ventricosum), and fescue (Vulpia sp.) all exhibited declines in occurrence. Only bluegrass (Poa sp.) and foxtailed brome grass (Bromus rubens) maintained or increased their occurrence. Foxtailed brome grass was the first grass species within the chaparral to emerge and complete its life cycle. Early emergents benefit in a dry year (such as 1987) by reproducing before competition with other grasses and forbs for soil moisture becomes intense.

Twenty-three species of forb were identified within the chaparral habitat in 1987 (Table 6). Sixteen species were present in 1981, 27 in 1983, and 28 in 1985. Three species--brodiea (Brodiea sp.), bull thistle (Cirsium vulgare), and vervain (Verbana sp.)--were recorded for the first time in 1987. Within the burned and unburned portions of the chaparral study area, 2.2 and 1.5 forb species per plot were present, respectively. The dominant forb species in 1987 (i.e., found in more than 10 percent of the plots) included bouncing bet (Saponaria officinalis), smooth cat's ear (Hypochoeris glabra), hemizonella (Madia minima), short-podded hosackia (Lotus humistratus), and selaginella (Selaginella hanseni).

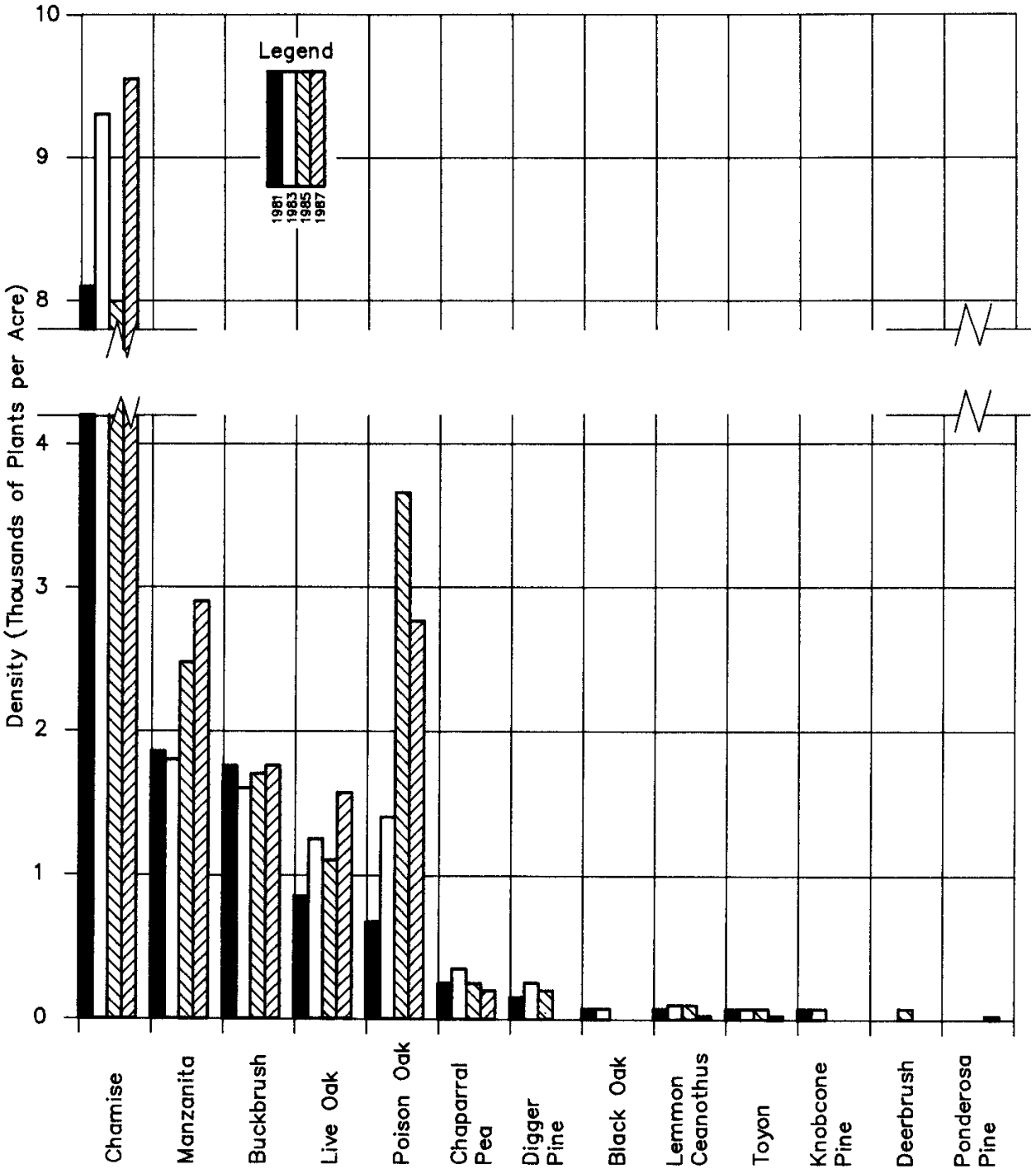

Figure 7. Shrub species composition of the chaparral study area.

Table 5. Percent occurrence of grasses within a 12-inch radius radius of each plot center in the chaparral study area.

Species	1981	1983	1985	1987
Aira caryophyllea	12.5	10.0	35.0	10.0
Bromus diandrus	-	-	2.5	-
Bromus mollis	7.5	10.0	20.0	17.5
Bromus rubens	7.5	5.0	25.0	25.0
Bromus tectorum	2.5	10.0	12.5	5.0
Gastridium ventricosum	-	-	2.5	-
Lolium sp.	5.0	-	-	-
Poa sp.	-	15.0	2.5	5.0
Sitanion sp.	5.0	-	-	-
Vulpia sp.	20.0	37.5	62.5	27.5
Unidentified bunchgrass	5.0	-	-	-

Table 6. Percent occurrence of forbs within a 12-inch radius of each plot center in the chaparral study area.

	1981	1983	1985	1987
Amaryllidaceae				
Allium bolanderi	-	2.5	-	5.0
Brodiaca sp.	-	-	-	2.5
Boraginaceae				
Plagiobothrys sp.	-	7.5	-	-
Cryptantha muricata	-	-	7.5	2.5
Campanulaceae				
Githopsis specularioides	-	-	2.5	-
Caryophyllaceae				
Arenaria douglasii	-	2.5	2.5	-
Saponaria officinalis	2.5	-	-	20.0
Stellaria media	-	10.0	7.5	2.5
Compositae				
Achillea borealis	2.5	-	-	-
Achyrachaena mollis	-	2.5	-	-
Agoseris sp.	-	-	5.0	-
Carduus pycnocephalus	-	-	7.5	10.0
Centaurea sp.	-	5.0	-	2.5
Cirsium vulgare	-	-	-	2.5
Hypochoeris glabra	-	2.5	15.0	15.0
Madia minima	2.5	7.5	22.5	15.0
Micropus californicus	-	2.5	-	-
Cruciferae				
Cardamine oligosperma	-	5.0	-	-
Thysanocarpus curvipes	-	-	2.5	2.5
Geraniaceae				
Erodium botrys	-	5.0	7.5	5.0
Hepaticae		2.5	-	2.5
Hydrophyllaceae				
Nemophila parviflora	2.5	2.5	2.5	-
Hypericaceae				
Hypericum concinnum	12.5	5.0	10.0	10.0
Juncaceae				
Lazula sp.	2.5	2.5	2.5	-
Labiatae				
Mentha pulegium	2.5	-	-	-
Scutellaria tuberosa	2.5	-	-	-
Leguminosae				
Astragalus gambellianus	-	2.5	2.5	-
Lotus humistratus	5.0	22.5	32.5	15.0
Trifolium sp.	2.5	-	-	-
Trifolium dichotomum	-	5.0	5.0	-
Liliaceae				
Calochortus amabilis	2.5	-	5.0	2.5
Linaceae				
Hesperolinon spergulinum	-	-	2.5	-
Onargraceae				
Epilobium minutum	-	17.5	7.5	-

Table 6 (cont'd.)

	1981	1983	1985	1987
Polemoniaceae				
Navarretia sp.	-	2.5	-	-
Portulacaceae				
Montia gypsophiloides	-	10.0	5.0	-
Montia perfoliata	-	-	7.5	2.5
Primulaceae				
Dodecatheon hendersonii	2.5	5.0	7.5	5.0
Pteridaceae				
Pityrogramma triangularis	-	2.5	2.5	2.5
Rubiaceae				
Galium aparine	2.5	-	5.0	2.5
Galium nuttallii	7.5	-	-	-
Scrophulariaceae				
Orthocarpus attenuatus	-	2.5	2.5	-
Pedicularis densiflora	-	2.5	2.5	-
Verbascum sp.	2.5	-	-	-
Selaginellaceae				
Selaginella hanseni	7.5	15.0	20.0	47.5
Umbelliferae				
Apiastrum angustifolium	-	2.5	2.5	2.5
Verbenaceae				
Verbana sp.	-	-	-	2.5

AMPHIBIANS AND REPTILES

Introduction

Amphibians and reptiles were monitored to evaluate how well species richness is being maintained on the leasehold. Geothermal development and even wildlife mitigation alter amphibian and reptile habitats. No mitigation was performed specifically for these species.

Methods

Amphibians and reptile data were collected through direct observation. Identifications were verified using Stebbins (1954). No attempts were made to estimate population sizes.

Results and Discussion

Three amphibian and nine reptile species were recorded on the leasehold during 1987 (Table 7), representing an increase of one reptile species but a loss of one amphibian species since 1981.

Amphibian species recorded in 1987 include western toad (Bufo boreas), Pacific tree frog (Hyla regilla), and rough-skinned newt (Taricha granulosa). California newt (Taricha torosa) is the only amphibian species which has been observed in a previous study and was not present in 1987.

Reptile species recorded in 1987 include western pond turtle (Clemmys marmorata), southern alligator lizard (Gerrhonotus multicarinatus), western fence lizard (Sceloporus occidentalis), western skink (Eumeces skiltonianus), gopher snake (Pituophis melanoleusus), western aquatic garter snake (Thamnopis couchi), racer (Coluber constrictor), striped racer (Masticophis lateralis), and western rattlesnake (Crotalus viridis). Striped racers had not previously been observed on the leasehold. No western terrestrial garter snakes (Thamnophis elegans) or common garter snakes (Thamnophis sirtalis) were observed on the leasehold in 1987. All species of garter snake require streams or moist areas (Houck 1979). Streams were pooled when the study began and very limited open water was present by May 15, 1987.

Table 7. Amphibian and reptile species identified in each study area.

Family	Scientific Name	Common Name	Black Oak Study Area				Chaparral Study Area			
			1981	1983	1985	1987	1981	1983	1985	1987
Bufonidae	Bufo boreas	Western toad	X	X			X	X		X
Hylidae	Hyla regilla	Pacific tree frog	X	X	X	X	X	X	X	
Salamandridae	Taricha granulosa	Rough-skinned newt	X	X	X	X			X	
	Taricha torosa	California newt			X					
Testudinidae	Clemmys marmorata	Western pond turtle	X	X	X	X				
Anguidae	Gerrhonotus multicarinatus	Southern alligator lizard	X	X	X	X	X	X	X	X
Iguanidae	Sceloporus occidentalis	Western fence lizard	X	X	X	X	X	X	X	X
Scincidae	Eumeces skiltonianus	Western skink	X	X	X	X				
Colubridae	Pituophis melanoleusus	Gopher snake	X	X	X		X	X		X
	Thamnophis couchi	Western aquatic garter snake	X	X	X	X				
	Thamnophis elegans	Western terrestrial garter snake	X	X						
	Thamnophis sirtalis	Common garter snake			X					
	Coluber constrictor	Racer		X	X	X		X	X	X
	Masticophis lateralis	Striped racer								X
Viperidae	Crotalus viridis	Western rattlesnake	X					X		X

Effects of Mitigation

No mitigation measures were designed specifically for amphibians or reptiles. However, mitigation employed to enhance habitat conditions for other animals may also benefit some species of reptiles and amphibians.

The 1982 controlled burn has increased structural habitat diversity within the chaparral study area. Six species of herps were present within the burned portion of the chaparral study area in 1987, including western toad, southern alligator lizard, western fence lizard, gopher snake, racer, and striped racer. Only one species (western fence lizard) was present within the burn unit in 1983. Three species (western fence lizard, racer, and Pacific tree frog) were observed within the burn unit in 1985. These observations correspond with those of Lillywhite and North (1974) and Lillywhite (1977), who demonstrated a strong correlation between habitat structural diversity and reptile community diversity. The high habitat diversity in the aforementioned studies was also the product of burning in chaparral habitat.

BIRDS

Introduction

Geothermal development of the Francisco Leasehold altered chaparral, forest, and riparian habitats. These habitat modifications may result in changes in the types of species able to utilize them. Avian population studies indicate the success of mitigation performed and identify those species which are not being maintained on the leasehold in viable numbers.

Methods

Bird observations began approximately 30 minutes after dawn and continued for 3.5 hours. Fifteen minutes were spent on each plot to record all birds seen or heard in the 165-foot by 165-foot plots. Birds were identified using 10X20 and 9X25 binoculars. Identifications were aided using field guides by Peterson (1961) and Robbins et al. (1983). All bird activity in a given plot was mapped on field data sheets during each plot visit. Field data sheets for 1981, 1983, 1985, and 1987 are on file at the Northern District office. Observations were not conducted during periods of rain or fog. The black oak study area received 273 plot visits in 1981, 280 in 1983, 312 in 1985, and 320 in 1987. The chaparral study area received 176 plot visits in 1981, 240 in 1983, 286 in 1985, and 280 in 1987.

Density indices were derived for each species in each study area. The indices were calculated using the formula: $D = (A - B) \times 1.618$, where D = the density index (birds/acre), A = the total number of individuals of a given species recorded, and B = the number of plot visits, commencing with the first sightings of the species and ending with the end of the study. The figure 1.618 simply converts hectares to acres. This method of data manipulation serves to lower the density estimates for migrant species observed only during the first few weeks of the study. The value produced by this method of data manipulation does not compensate for the variation in detectability between species and should not be considered a true density estimate. A given species population may, however, be compared from year to year.

Violet-green swallows (Tachycineta thalassina) were not inventoried during any of the studies. This species occurred in large numbers over most plots throughout the study periods. An accurate census of violet-green swallows would have affected the quality of the data for other species by requiring an inordinate amount of time for observation and recording.

Results and Discussion

Ninety-six species (Appendix B) have been observed on the leasehold during the four collective wildlife studies (1981, 1983, 1985, and 1987).

Black Oak Study Area

Eighty-two species have been observed in this study area during the four years of population analyses. Two species (Table 8) were present in 1987 that had not previously been observed in the black oak study area. These species are lark sparrow (Chondestes grammacus) and Wilson's warbler (Wilsonia pursilla). Species richness of 55 in 1981, 59 in 1983, 59 in 1985, and 61 in 1987 were recorded. Forty-six percent of the species were present during all four years of population analysis. Seventy-eight percent of the species present in 1981 were again present in 1987.

The total density of birds was 8.97/acre in 1981, 14.2 birds/acre in 1983, 12.9 birds/acre in 1985, and 11.4 birds/acre in 1987. Total density has declined steadily since 1983, but remained greater than the 1981 density. Species diversity has remained stable between study periods, as indicated by Shannon-Weaver diversity indices of 5.0, 4.9, 5.0, and 4.9 for 1981, 1983, 1985, and 1987, respectively. Equitabilities have fluctuated subtly from 0.85 in 1981 to 0.73 in 1987, with values of 0.74 in 1983 and 0.79 in 1985.

The dominant species in this study area during 1987 included lesser goldfinch (Cardeulis psaltria), acorn woodpecker (Melanerpes formicivorous), Brewer's blackbird (Euphagus cyanocephalus), and purple finch (Cardpodacus purpureus). Of these four dominant species in 1987, only one (Brewer's blackbird) was considered a dominant in 1981.

Chaparral Study Area

Sixty-five species have been documented within the chaparral study area during the four wildlife studies. Species richness of 37, 44, 45, and 50 were recorded in 1981, 1983, 1985, and 1987, respectively (Table 9). Six species (band-tailed pigeon [Columba fasciata], killdeer [Charadrius vociferus], lark sparrow, lazuli bunting [Passerina amoena], purple martin [Progne subis], and varied thrush [Ixoreus naevius]) were present in 1987 which had not previously been inventoried within the chaparral study area. Twenty-eight species (43 percent) have been present during each of the four studies. Total density has increased steadily since 1983. Total density was 6.3 birds/acre in 1981, 6.0 birds/acre in 1983, 7.6 birds/acre in 1985, and 9.8 birds/acre

Table 8. Bird density indices for 1981, 1983, 1985, and 1987 within the black oak study area.

	Birds/Acre			
	1981	1983	1985	1987
acorn woodpecker	0.30	0.95	0.41	0.78
Allen's hummingbird	-	0.08	-	-
American kestrel	-	0.01	-	0.06
American robin	0.81	1.28	0.75	0.67
Anna's hummingbird	0.03	0.24	0.02	0.02
ash-throated flycatcher	-	-	0.38	0.08
band-tailed pigeon	0.44	0.02	-	0.06
barn swallow	0.06	0.25	0.24	0.20
black-chinned hummingbird	0.02	0.13	0.05	0.17
black-headed grosbeak	0.38	1.12	0.58	0.58
black-throated gray warbler	0.04	0.08	0.14	0.03
blue-gray gnatcatcher	-	-	0.23	-
Brewer's blackbird	0.81	1.58	1.97	1.22
brown creeper	-	-	0.02	0.09
brown-headed cowbird	0.09	0.07	0.51	0.14
brown towhee	0.06	0.16	0.10	0.09
California quail	0.22	0.16	0.10	0.09
California thrasher	-	0.04	-	-
Cassin's finch	0.02	-	-	-
cedar waxwing	-	0.76	-	0.06
chestnut-backed chickadee	0.12	-	0.06	0.03
chipping sparrow	0.12	0.03	0.03	-
cliff swallow	-	-	0.46	0.01
common bushtit	-	0.08	0.23	0.22
common crow	0.01	0.05	0.02	-
common flicker	0.10	0.36	0.13	0.26
common raven	0.04	0.08	0.09	0.26
Cooper's hawk	-	-	0.01	0.02
dark-eyed junco	0.24	0.57	0.37	0.54
downy woodpecker	0.03	0.01	0.01	0.04
empidonax flycatchers	0.23	0.31	0.21	0.01
fox sparrow	-	0.01	-	-
green heron	-	-	0.01	-
golden-crowned sparrow	0.02	0.04	-	-
hairy woodpecker	-	0.01	-	0.01
hermit thrush	0.01	-	-	-
house finch	0.14	0.13	0.15	0.07
house sparrow	0.01	-	-	-
house wren	0.28	0.19	0.57	0.09
Hutton's vireo	0.21	0.12	0.01	0.10
killdeer	0.06	0.05	0.06	0.08
lark sparrow	-	-	-	0.03
Lawrence's goldfinch	0.09	-	0.05	0.24
lesser goldfinch	0.34	0.19	0.48	0.89
mallard	-	0.02	0.01	-
mockingbird	-	0.01	-	-

Table 8. (cont'd.)

	Birds/Acre			
	1981	1983	1985	1987
mountain quail	-	0.03	0.01	-
mourning dove	0.22	0.26	0.05	0.11
Nashville warbler	-	-	0.65	0.36
northern oriole	0.20	0.32	0.28	0.06
orange-crowned warbler	0.01	0.24	0.04	0.12
peacock	-	0.08	-	0.21
pileated woodpecker	-	0.02	0.01	0.08
pine sisken	-	0.04	-	0.01
plain titmouse	0.51	0.54	0.42	0.28
pygmy nuthatch	0.02	0.06	0.12	-
purple finch	-	0.25	0.49	0.79
red crossbill	0.01	-	-	-
red-tailed hawk	-	-	0.02	0.01
red-winged blackbird	0.25	0.02	0.03	0.03
ruby-crowned kinglet	0.11	0.09	0.10	0.11
rufous-sided towhee	0.45	0.29	0.23	0.29
savannah sparrow	0.14	-	-	-
screech owl	-	0.01	-	0.01
scrub jay	0.08	0.10	0.11	0.19
sharp-shinned hawk	0.01	0.01	-	-
solitary vireo	0.05	-	0.20	-
starling	0.44	1.16	0.40	0.40
stellar's jay	0.08	0.17	0.05	0.07
tree swallow	0.02	0.15	0.08	0.03
turkey vulture	0.04	0.01	0.03	0.02
varied thrush	0.01	-	-	-
warbling vireo	-	-	0.02	-
western bluebird	0.53	0.38	0.34	0.51
western kingbird	0.12	-	0.03	0.09
western tanager	0.12	0.17	0.15	0.19
white-breasted nuthatch	0.15	0.29	0.33	0.18
white-crowned sparrow	0.01	0.08	-	0.05
Wilson's warbler	-	-	-	0.01
yellow-headed blackbird	0.01	-	-	0.03
yellow-rumped warbler	0.05	0.22	0.16	0.51
yellow warbler	-	-	0.03	0.02

Table 9. Bird density indices for 1981, 1983, 1985 and 1987 within the chaparral study area.

	Birds/Acre			
	1981	1983	1985	1987
acorn woodpecker	0.10	0.19	0.22	0.31
American robin	0.33	0.10	0.01	0.07
Anna's hummingbird	-	-	0.01	0.01
ash-throated flycatcher	-	-	0.24	0.16
band-tailed pigeon	-	-	-	0.12
barn swallow	-	0.15	0.18	0.13
Bewick's wren	0.17	0.40	0.32	0.58
black-chinned hummingbird	0.08	0.25	0.35	0.46
black-headed grosbeak	-	-	0.05	0.04
black phoebe	0.01	-	-	0.03
blue-gray gnatcatcher	0.21	0.18	0.30	0.45
Brewer's blackbird	0.14	0.13	0.20	0.25
brown-headed cowbird	0.03	-	-	-
brown towhee	0.13	0.19	0.28	0.34
California quail	0.27	0.04	0.10	0.37
California thrasher	0.27	0.12	0.03	0.09
chipping sparrow	-	0.01	-	0.02
cliff swallow	-	0.01	0.57	0.04
common bushtit	0.27	0.02	0.09	0.45
common crow	0.08	0.08	0.01	-
common flicker	0.06	0.08	0.07	0.09
common raven	-	0.01	0.12	0.14
dark-eyed junco	1.00	0.04	0.81	-
downy woodpecker	-	-	0.02	-
empidonax flycatchers	0.03	0.32	0.05	0.01
fox sparrow	-	0.01	-	0.01
golden-crowned sparrow	0.10	0.11	0.12	0.27
great horned owl	-	0.04	-	-
hairy woodpecker	-	0.01	0.01	0.06
hermit thrush	0.04	0.08	0.03	0.09
house finch	-	0.05	0.12	-
house wren	0.02	-	-	-
killdeer	-	-	-	0.2
lark sparrow	-	-	-	0.02
Lawrence's goldfinch	-	-	0.12	-
Lazula bunting	-	-	-	0.01
lesser goldfinch	0.07	0.20	0.34	1.12
mountain quail	0.09	0.08	0.08	0.04
mourning dove	0.07	0.03	0.03	0.14
northern oriole	0.16	0.04	0.05	0.03
orange-crowned warbler	0.02	0.44	0.08	0.10
pileated woodpecker	-	-	0.01	-
plain titmouse	0.41	0.11	0.16	0.08
purple finch	-	0.02	0.42	0.13
purple martin	-	-	-	0.01
red-tailed hawk	-	-	0.01	-

Table 9 (cont'd.)

	Birds/Acre			
	1981	1983	1985	1987
red-winged blackbird	0.03	0.07	0.03	0.02
rough-winged swallow	-	0.08	0.01	0.02
ruby-crowned kinglet	-	0.02	-	-
rufous-sided towhee	0.69	0.53	0.99	0.96
sage sparrow	0.27	0.08	0.02	0.24
scrub jay	0.44	0.55	0.65	0.79
song sparrow	0.01	-	-	-
starling	0.13	0.03	0.02	0.03
Stellar's jay	0.01	-	-	-
turkey vulture	0.04	0.10	0.04	0.03
varied thrush	-	-	-	0.01
vesper sparrow	-	0.02	-	-
western bluebird	0.01	0.20	0.03	0.20
western kingbird	0.06	-	0.03	0.18
western tanager	-	-	0.01	0.02
white-crowned sparrow	0.07	0.11	-	0.03
white-breasted nuthatch	-	-	0.01	0.01
wrentit	0.97	1.00	0.88	0.94
yellow-headed blackbird	-	0.04	-	-

in 1987. Total density of birds has increased 56 percent since 1981. Species diversity indices have remained relatively stable at 4.3, 4.6, 4.5, and 4.4 in 1981, 1983, 1985, and 1987, respectively. Equitability has declined steadily since 1983. Equitability was 0.80 in 1981, 0.83 in 1983, 0.75 in 1985, and 0.62 in 1987. The dominant species in the chaparral study area in 1987 included Bewick's wren (Thryomanes bewickii), lesser goldfinch (Carduelis psaltria), rufous-sided towhee (Pipila erythrophthalmus), scrub jay (Aphelocoma coerulescens), and wrentit (Chamaea fasciata). Rufous-sided towhee, scrub jay, and wrentit were also among the dominant species in 1981.

Effects of Mitigation

Nest box utilization (Figure 8) increased annually until 1986. Utilization declined to 62 percent in 1986 and 40 percent in 1987. However, nest box utilization in 1987 was still greater than that in 1982 (17 percent) and 1983 (34 percent). Seven secondary cavity nesting species have utilized the nest boxes (Table 10).

Table 10. Percent nest box utilization by species.

Species	1982	1983	1984	1985	1986	1987
house wren (Troglodytes aedon)	2	2	8	12	12	4
plain titmouse (Parus inornatus)	4	6	4	8	2	2
white-breasted nuthatch (Sitta carolinensis)	-	2	6	8	8	2
ash-throated flycatcher (Myiarchus cinerascens)	-	-	-	2	4	-
violet-green swallow (Tachycineta thalassina)	-	14	22	38	26	16
tree swallow (Tachycineta bicolor)	8	4	-	-	-	-
western bluebird (Sialia mexicana)	2	6	6	6	10	16

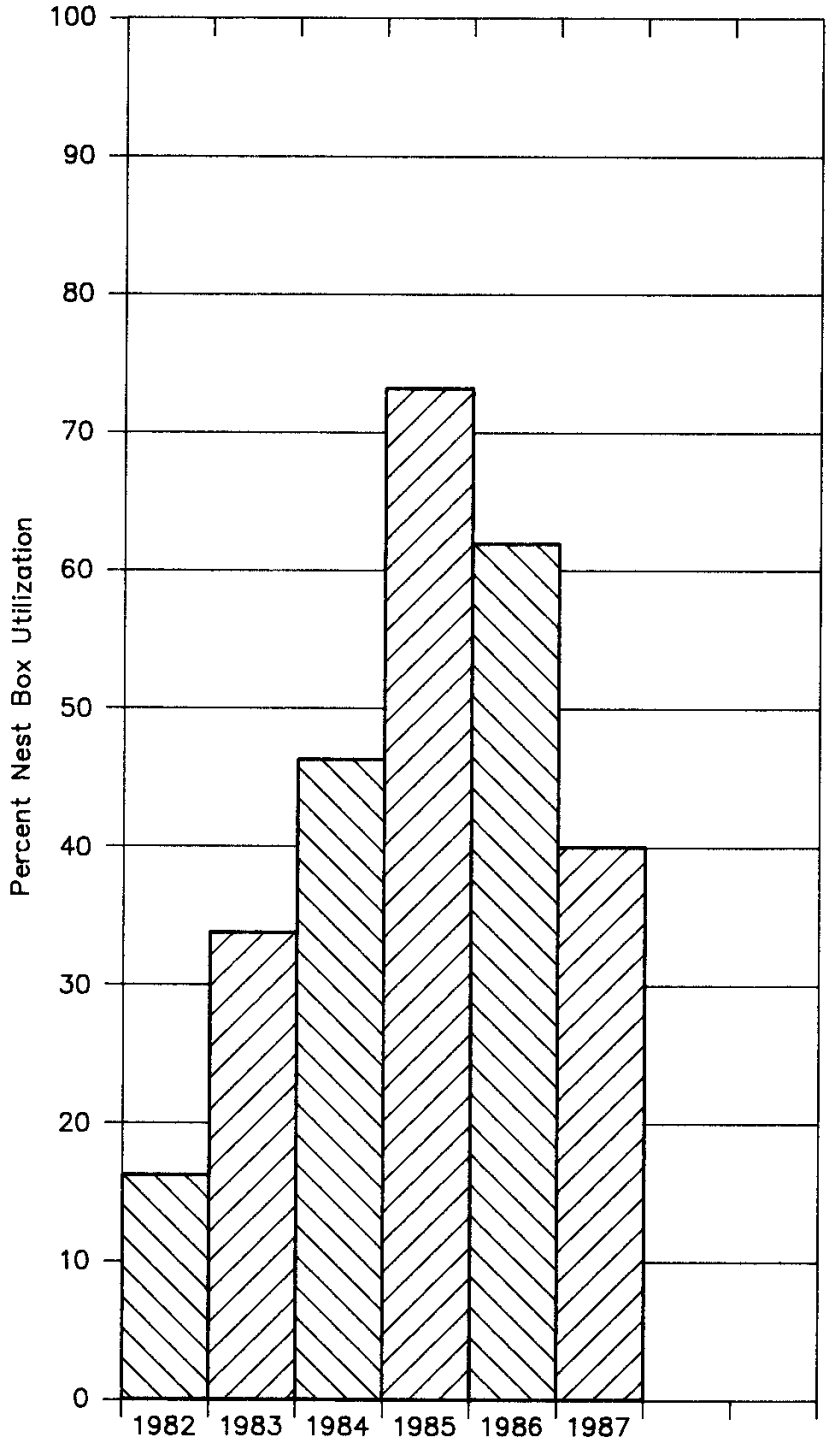

Figure 8. Percentage utilization of nest boxes.

The density of secondary cavity nesters (species which utilize the size of boxes available) was 1.44 birds/acre in the 12.5-acre portion of the black oak study area containing nest boxes and 1.01 birds/acre in the 12.5-acre control area (Table 11).

Table 11. Comparison of secondary cavity nester densities in the area containing nest boxes and in the control.

Year	Control	Nest Boxes
1981	1.0	0.4
1982	- - - - - - - nest boxes installed	
1983	0.6	0.9
1985	1.43	2.81
1987	1.01	1.44

Nest boxes have raised the density of secondary cavity nesters in the 12.5 acres where boxes are present by as much as 700 percent above pre-project levels. The decrease in nest box utilization since 1985 is paralleled by a decrease in the density of secondary cavity nesters. All secondary cavity nesting species (except western bluebirds) exhibited a decrease in nest box utilization in 1987. Western bluebirds increased their nest box use by 10 percent in 1987. The annual fluctuations in the density of secondary cavity nesters since 1983 followed the same trend in the control area as in the area containing nest boxes.

Starlings (Sturnus vulgaris), a common species during each study, have not utilized either the large-holed nest boxes designed for them or the nest boxes with woodpecker-enlarged holes. The presence of resident screech owls has been documented to prevent starlings from utilizing nest boxes (Van Camp and Henry 1975).

Kenga (1961) found that nest boxes contained a higher concentration of blowfly larvae (a common ectoparasite of cavity-nesting birds) than in natural cavities. Blowflies (Apaulina sp.) can reduce nesting success by weakening or killing nestlings (Pinkowski 1977). During a two-year nest box study in an Arizona ponderosa pine forest, blowfly larvae were found only in the second nest of bluebirds (Brown and Balda 1983). No relationship between the

incidence of parasitism and nesting success was found in the aforementioned study. An analysis of nest material gathered from nest boxes on the Francisco Leasehold in 1987 indicated a high level of blowfly infestation (as indicated by pupal cases) in grass nests. Blowfly infestations can lead to decreased use of nest boxes.

During 1982, five acres of old growth mixed chaparral habitat were burned to increase habitat diversity within the chaparral study area. The burn increased both structural diversity and plant species diversity within the chaparral study area. Structural diversity has been identified as an important factor influencing bird species composition and abundance (MacArthur and MacArthur 1961, Karr and Roth 1971, Wilson 1974, Roth 1976). Bird species are also influenced by the diversity of plant species, independent of structural considerations (MacArthur and MacArthur 1961, Holmes and Robinson 1981, Robinson and Holmes 1984).

Species richness has increased within the burn unit from 27 species in 1981 to 28 species in 1983, to 30 species in 1985, to 32 species in 1987. Approximately 66 percent of the chaparral bird species in 1987 occurred at an equal or greater density within the burned unit than in the control. Total density of bird species was 10.2 birds/acre in the burn compared to 9.4 birds/acre in the control (Table 12). Diversity indices were slightly greater within the control (4.4), compared to the burn (4.2). Equitability, however, was much greater in the burn unit (0.82) than in the control (0.65).

Table 12. Total bird density within the burned and unburned portion of the chaparral study area.

Year	Control	Burn
1981	7.0	6.1
1982	burn conducted June 8, 1982	
1983	6.9	5.2
1985	5.3	10.4
1987	9.4	10.2

Acorn woodpeckers, orange-crowned warblers (Vermivora celata), wrentit, common ficker (Colaptes auratus), blue-gray knatcatcher (Polioptila caerulea), and California thrasher (Toxastoma redivivum) all occurred at significantly greater densities within the control unit in 1987. California quail (Callipepla californica), common raven (Corvus corax), western bluebird, mourning dove, cliff swallow (Hirundo fulva), and golden-crowned sparrow (Zonotrichia atricapilla) densities were significantly greater within the burn unit in 1987. Increased species richness and density of breeding birds during the first four or five years following chaparral fire are reported by Lawrence (1966) and Wirtz (1977). Rapid succession from a herb/grass seral stage to a shrub- dominated stage reduces both structural and plant species diversity, which in turn reduces bird species diversity. As shrub cover increases within the burn unit, bird species richness, total density and diversity will become increasingly similar between the burn unit and the control.

MOURNING DOVE
(Zenaida macroura)

Introduction

Mourning doves were identified as a species whose population could be negatively impacted by geothermal development of the Francisco Leasehold (DWR 1979). Mitigation in the form of nest cones was developed and implemented to offset these projected adverse impacts.

Methods

Mourning doves were inventoried, utilizing the technique previously described in the bird section of this report, in both the black oak and chaparral study areas. Nest cones were monitored in May and July for nesting activity.

Results and Discussion

Dove-nesting activities were observed during late May in a small (i.e., less than 25 feet tall) black oak located adjacent to the Francisco well pad. No nest had been constructed by May 29, 1987.

Mourning dove density estimates indicate a 50-percent decrease in the dove population within the black oak study area since the baseline study, while chaparral dove densities have doubled since 1981 (Table 13).

Table 13. Mourning dove density estimates (doves/acre) in the black oak and chaparral study areas.

	1981	1983	1985	1987
Black oak study area	0.22	0.26	0.05	0.11
Chaparral study area	0.07	0.03	0.03	0.14
Total	0.29	0.29	0.08	0.25

Total dove density was slightly (14 percent) below baseline levels. Mourning dove density was approximately ten times greater within the burned portion of the chaparral study area than in the unburned area. Increased mourning dove use following chaparral fire is well documented (Biswell et al. 1952, Biswell 1961, Lawrence 1966, and Longhurst 1978). Increased seed availability during the grass forb seral stage attracts doves to burned areas (Sweeney 1954).

Effects of Mitigation

Fifty dove nest cones were installed in the black oak study area in 1982. These cones have been annually monitored for nesting activity. No nesting or attempted nesting by any species has occurred. The use of dove cones has been ineffective in maintaining the dove population on the leasehold.

SMALL MAMMALS

Introduction

Small sedentary wildlife species were identified as the types of species most likely to be adversely affected by geothermal development on the leasehold (DWR 1979). Small mammal populations are monitored on the leasehold to quantify the effectiveness of mitigation measures employed to maintain their density and diversity.

Methods

Five representative trap units, each comprising 2.5 acres (Figure 2), were trapped for two consecutive weeks, beginning April 13 in the meadow-edge trap unit. Trap units in order of sampling include meadow-edge, black oak woodland with heavy understory, oak woodland with light understory, old growth mixed chaparral, and chamise chaparral. Each habitat unit was comprised of four 165-by-165-foot plots, which were each sampled with 40 traps aligned along assessment lines (Figure 9).

Each habitat unit was sampled during the first week of the population survey for three consecutive nights with "Sherman" live traps. The traps were baited with peanut butter and rolled oats. Each trap was checked daily, approximately four hours after sunrise. Each newly captured individual was identified, using keys in Burt and Grossenheider (1964) and Ingles (1965), sexed, aged, and fitted with a numbered ear tag before being released. All recaptured animals were identified by ear tag number, recorded, and released. Trapping results were expressed as catch/100 trap nights for each species rather than a density estimated.

The following week, the same habitat unit was resampled in exactly the same manner described above, except that museum special snap traps were used. Trapped specimens were aged, sexed, and keyed to species. Snap trap data were also recorded as catch/100 trap nights.

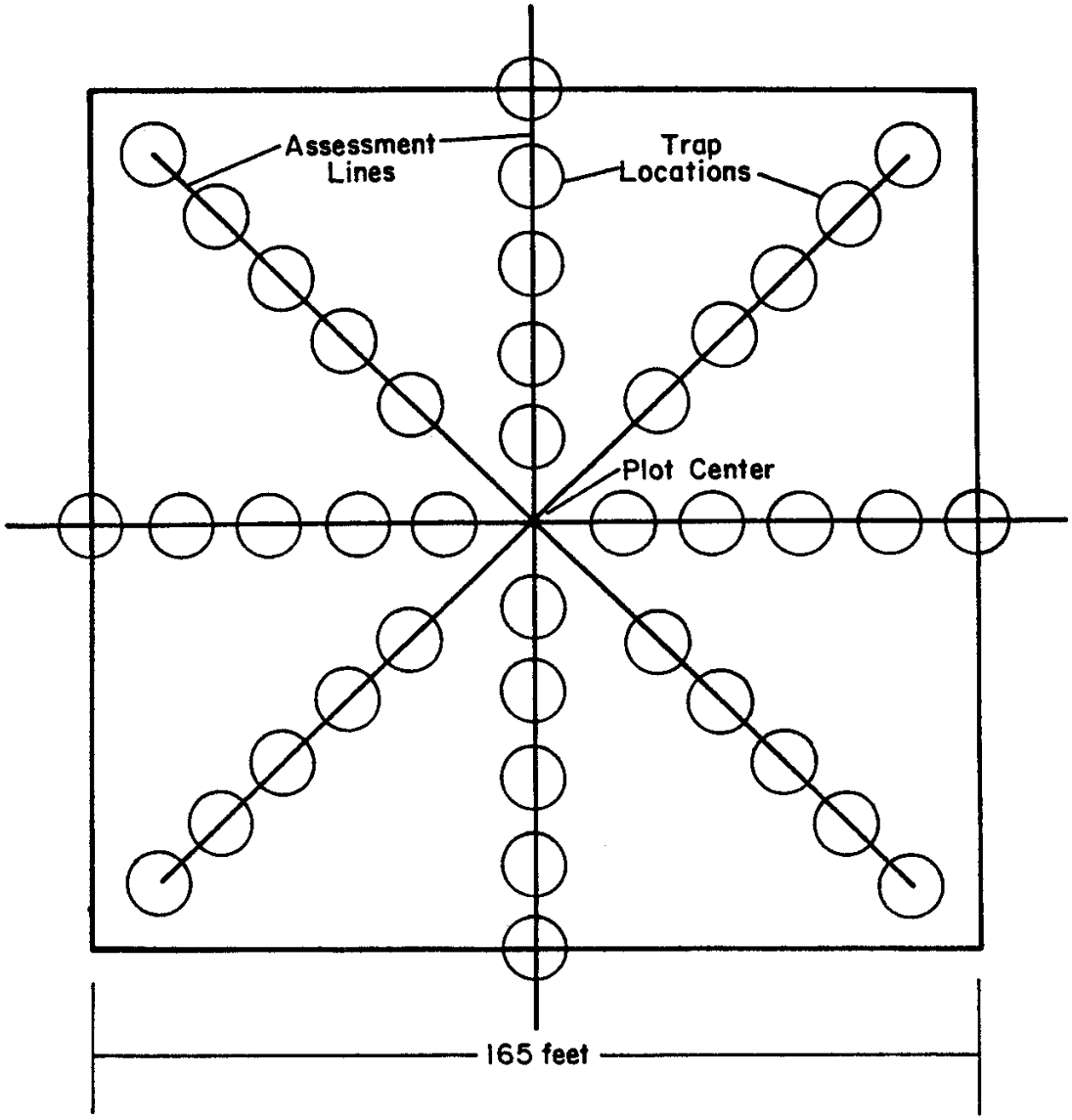

Figure 9. Study plot configuration for small mammal trap units (after O'Farrell et al. 1977).

Results and Discussion

Twelve small mammal species were recorded on the leasehold during 1987 compared to 13 in 1981 (Table 14). Two species present in 1981 have not been found since: the western harvest mouse (Reithrodonomys megalotis) and chickaree (Tamiasciurus douglasi).

Meadow-Edge Trap Unit

Ground cover data indicate moderate change within this trap unit since 1981 (Figure 10). These changes are characterized by a moderate increase in erosion pavement, a moderate decrease in grass and forb cover, a substantial increase in litter, and a substantial decrease in shrub cover. The 1987 ground cover composition data were collected earlier in relation to plant phenology than in past studies. Few grass and forb species had emerged, so oak litter and erosion pavement still covered much of the ground surface. Shrub cover in the past (1981, 1983, and 1985) has been comprised largely of young oaks. Many of these young oaks no longer have live branches within the shrub layer (i.e., less than 4 feet from the ground surface) and were not included as shrub cover.

Pinyon mouse (Peromyscus truei) is the only small mammal species consistently captured within this unit (Figure 11). Pinyon mice populations show an upward trend since 1981. The 1987 catch was approximately four times that of the 1981 catch. Western harvest mice have not been captured within this unit since 1981. Sonoma chipmunks (Eutamias sonomae) were observed within this unit in 1987, but eluded capture.

Heavy Understory Black Oak Woodland Trap Unit

Ground cover composition has remained relatively constant in this unit since 1981 (Figure 12).

Pinyon mice and deer mice (Peromyscus maniculatus) have been captured consistently within this unit (Figure 13). Both species populations remained below baseline levels. Pinyon mouse captures were less than baseline levels by approximately 28 percent. Deer mouse captures have declined 70 percent since 1981. Western harvest mice, California vole (Microtus californicus), and Trowbridge shrew were not captured within this unit in 1987. Dusky-footed woodrat (Neotoma fuscipes) captures exceeded those of previous years by 97 percent. Limited woodrat habitat was present in this unit. All woodrat captures within this trap unit were associated with large dead and downed trees.

Table 14. Small mammal species identified in each study area.

Scientific Name	Common Name	1981		1983		1985		1987	
		CH	BO	CH	BO	CH	BO	CH	BO
Microtus californicus	California vole		X		X	X	X	X	
Neotoma fuscipes	dusky-footed woodrat	X	X	X	X	X	X	X	X
Peromyscus boylii	brush mouse							X	
Peromyscus truei	pinyon mouse	X	X	X	X	X	X	X	X
Peromyscus maniculatus	deer mouse	X	X	X	X	X	X	X	X
Reithrodonomys megalotis	western harvest mouse		X						
Dipodomys heermanni	Heermann kangaroo rat	X						X	
Thomomys bottae	valley pocket gopher		X		X		X	X	X
Tamiasciurus douglasi	chickaree	X							
Eutamias sonomae	Sonoma chipmunk	X		X	X	X	X	X	X
Sorex trowbridgei	Trowbridge shrew	X	X	X	X		X		
Sylvilagus bachmani	brush rabbit	X		X		X	X	X	X
Lepus californicus	black-tailed jackrabbit	X	X	X	X	X	X	X	X
Scapanus latimanus	broad-handed mole				X		X		X
Citellus beechyi	California ground squirrel				X		X		
Sciurus griseus	western gray squirrel		X		X	X	X		X

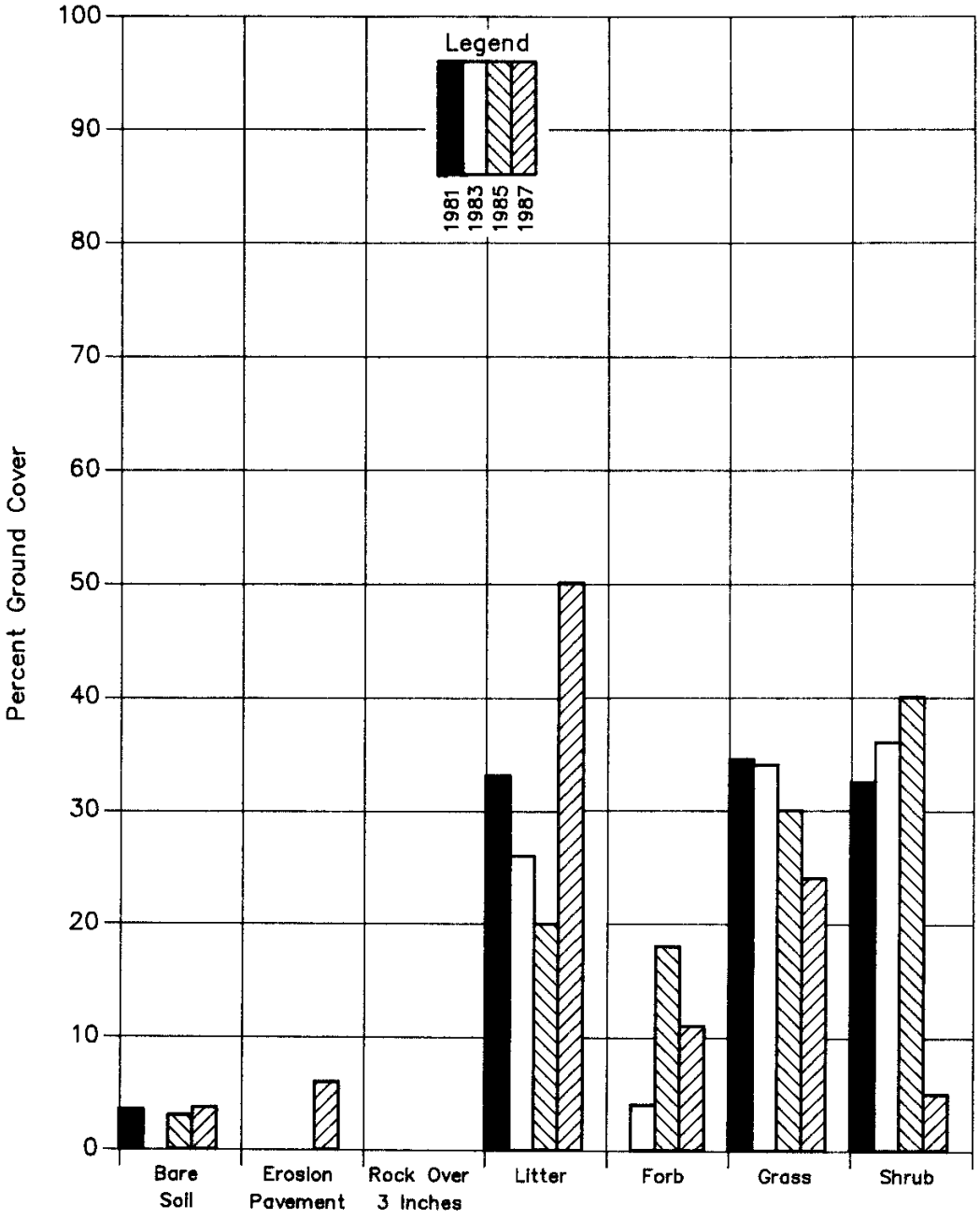

Figure 10. Ground cover composition for the meadow–edge trap unit.

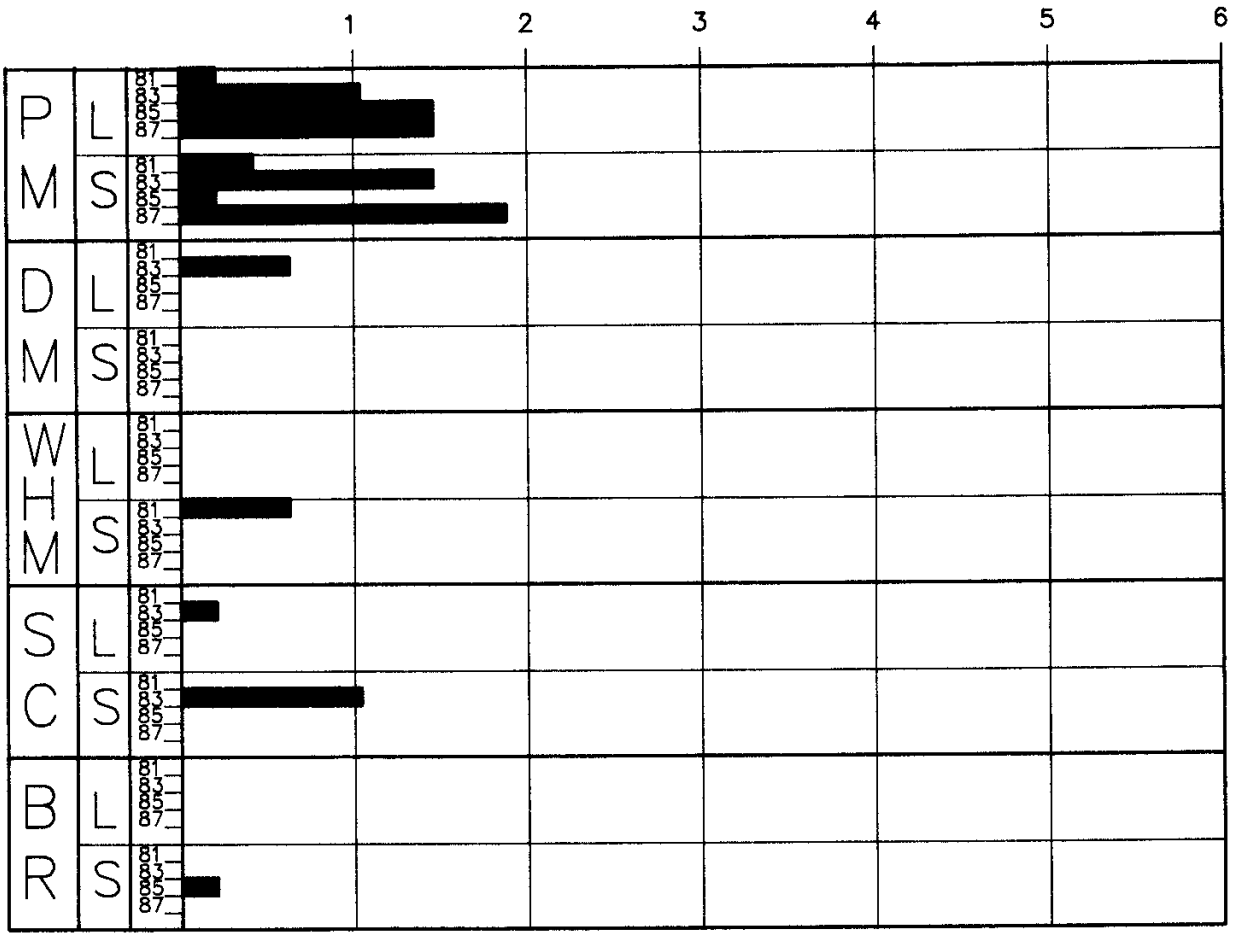

Figure 11. Small mammal catch per 100 trap nights for the meadow–edge trap unit (L=live trap, S=snap trap, PM=pinyon mouse, DM=deer mouse, WHM=western harvest mouse, SC=Sonoma, chipmunk, BR=brush rabbit).

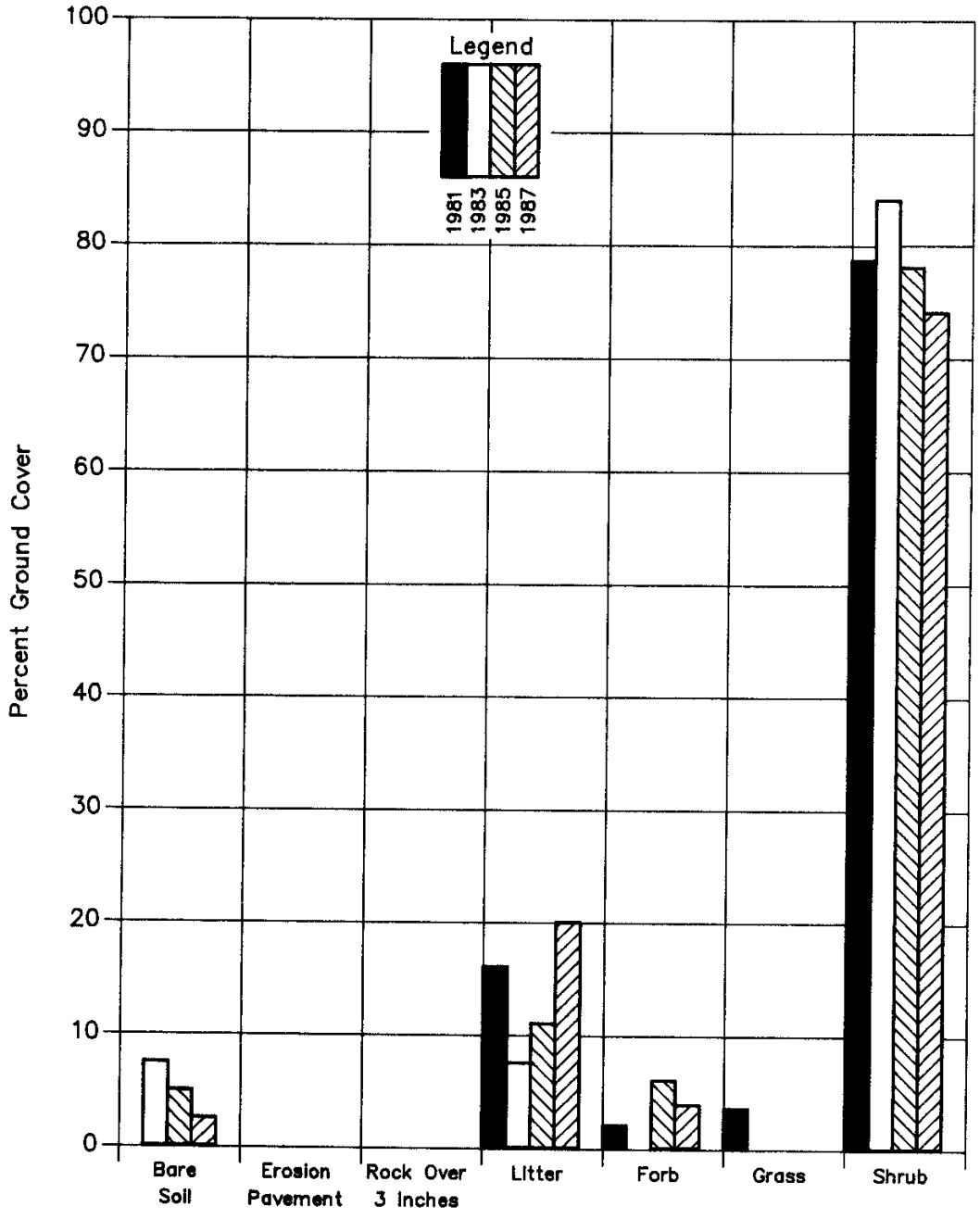

Figure 12. Ground cover composition for the heavy understory black oak woodland trap unit.

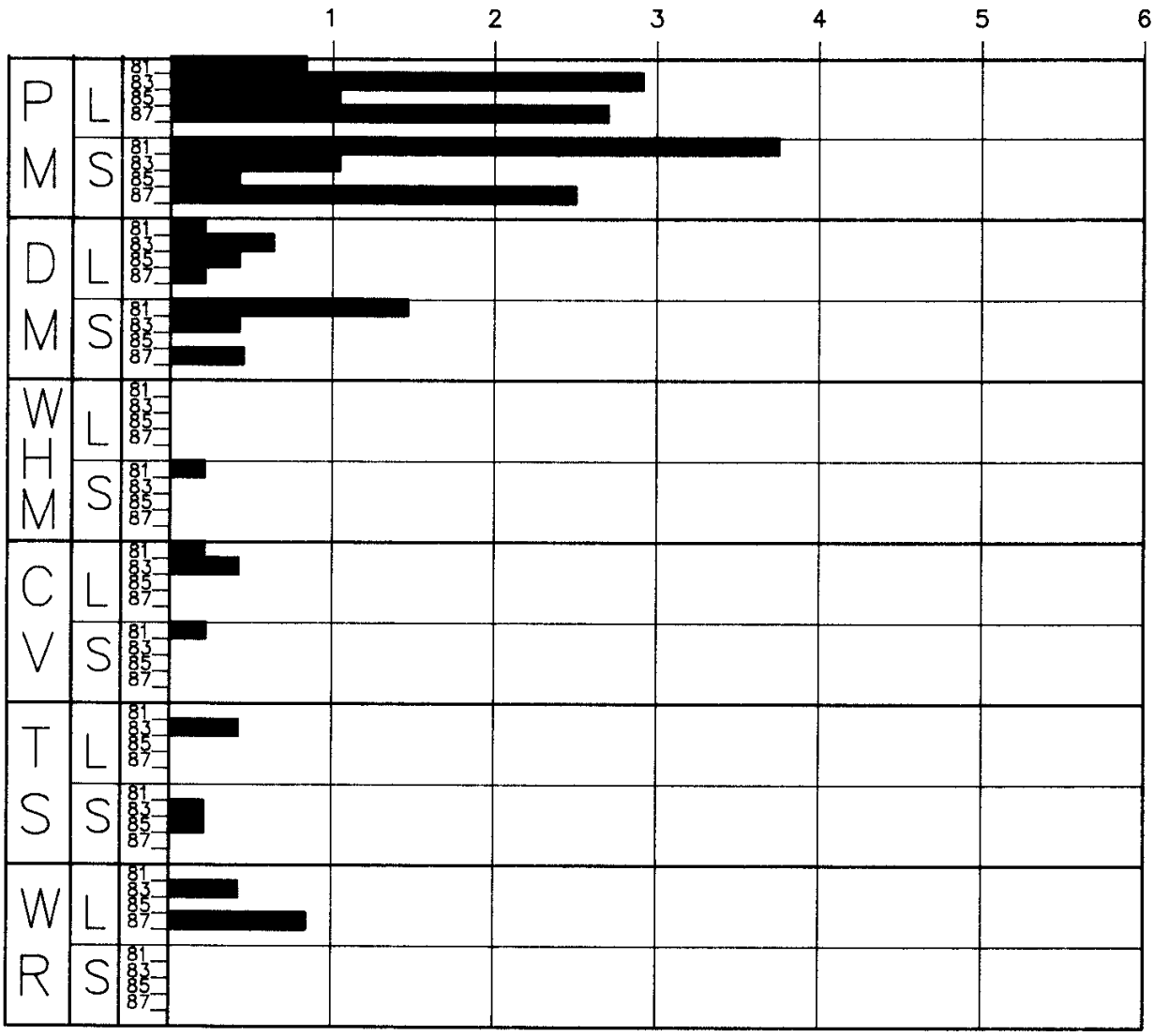

Figure 13. Small mammal catch per 100 trap nights for the heavy understory black oak woodland trap unit (L=live trap, S=snap trap, PM=pinyon mouse, DM=deer mouse, WHM=western harvest mouse, CV=California vole, TS=Trowbridge shrew, WR=dusky-footed woodrat).

Light Understory Black Oak Woodland Trap Unit

The light understory black oak woodland trap unit was severely impacted by road and steamline construction in 1981. Shrub and tree removal has limited small mammal habitat within this trap unit. Pinyon mice require brushy ground cover and ground litter, both of which have been significantly reduced since 1981. These construction activities did not affect the plot centers and are not reflected in the ground cover composition data for this unit (Figure 14). The reduction of shrub cover in 1987 represents the loss of young oak from the shrub layer.

Pinyon mouse populations have decreased approximately 76 percent since 1981 (Figure 15). Deer mouse captures have decreased 34 percent since 1981. Total small mammal captures have declined approximately 70 percent since the baseline study. California voles have not been captured in this unit since 1981.

Low Chamise Chaparral Trap Unit

Vegetative changes within this unit have been negligible (Figure 16).

Total small mammal captures have declined approximately 75 percent in this trap unit since 1981 (Figure 17). Pinyon mouse captures have declined 50 percent since 1981. Woodrat captures have declined 91 percent from baseline levels. Woodrats generally exhibit very low population fluctuations from year to year in undisturbed habitat (Lindsdale and Tevis, 1951). No deer mice were captured in 1987, and no kangaroo rats (Dipodomys heermanni) have been captured since 1981. A California vole was captured in unusual habitat (dense brush) in 1987. The small mammal population declines observed in this trap unit do not appear to be linked to any measured habitat parameter.

Old-Growth Mixed Chaparral Trap Unit

The old-growth mixed chaparral trap unit was manipulated through controlled burning in 1982. Plant succession following the burn is illustrated in Figure 18. Shrub cover is slowly replacing grasses within the burn unit, as shrub sprouts continue to grow in height and diameter.

Small mammal populations decreased significantly following the 1982 burn (Figure 19). The total small mammal catch declined 55 percent between 1981 and 1983. Total catch has declined an additional 16 percent since 1983. The pinyon mouse population declined approximately 71 percent since 1981.

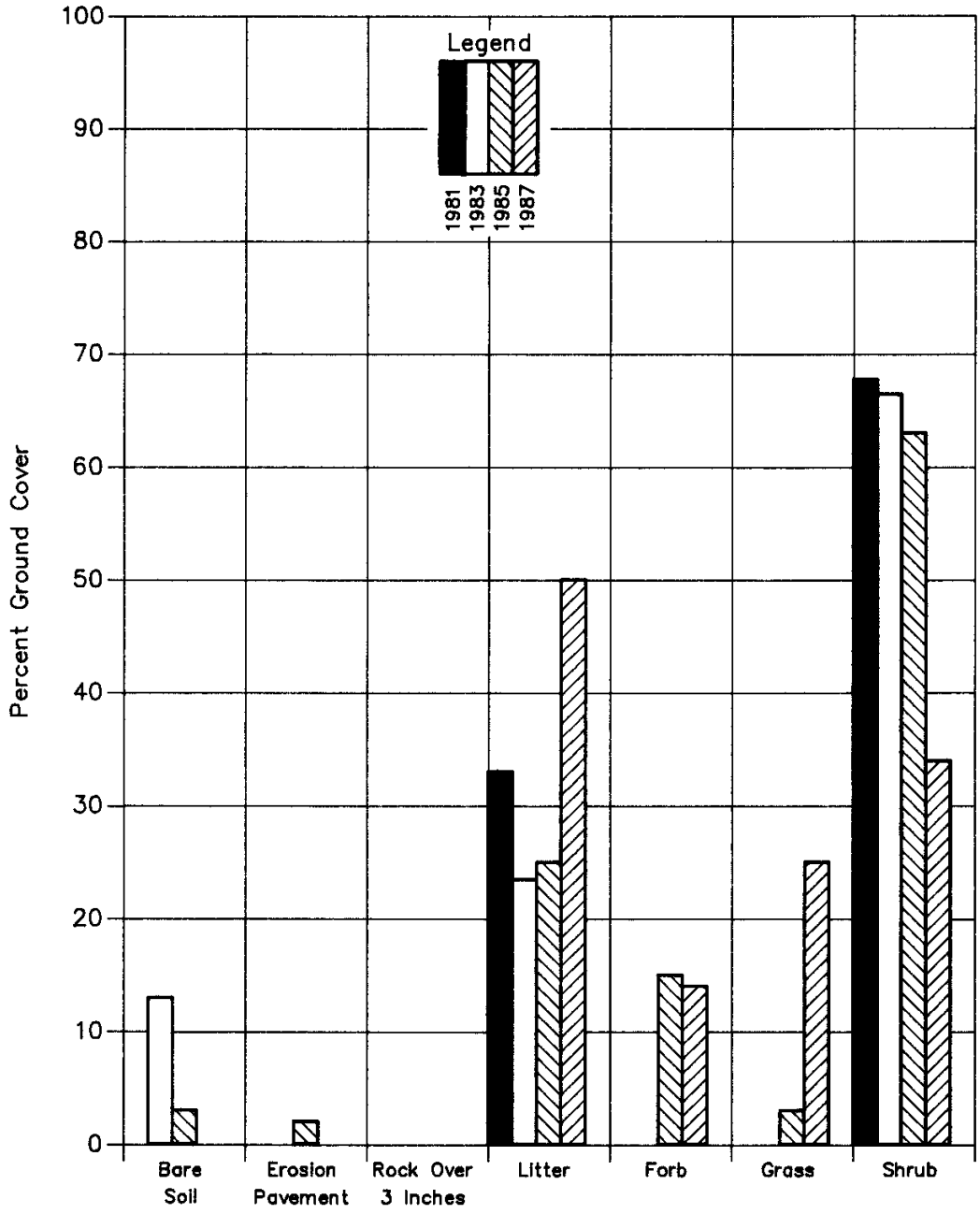

Figure 14. Ground cover composition for the light understory black oak trap unit.

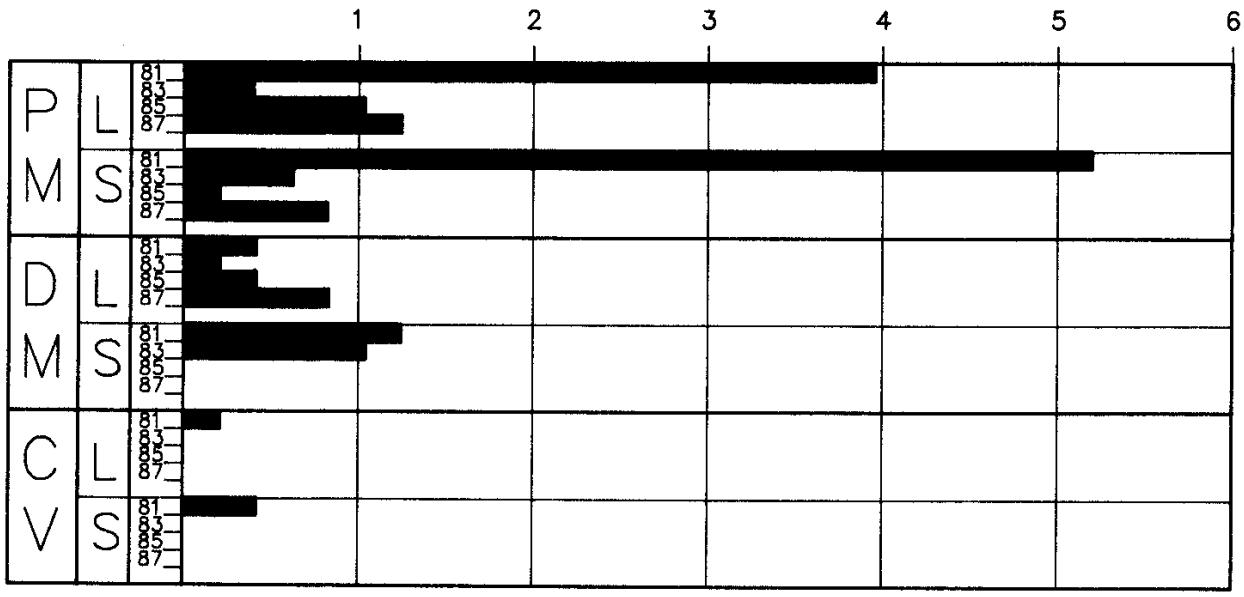

Figure 15. Small mammal catch per 100 trap nights for the light understory black oak woodland trap unit (L=live trap, S=snap trap, PM=pinyon mouse, DM=deer mouse, CV=California vole).

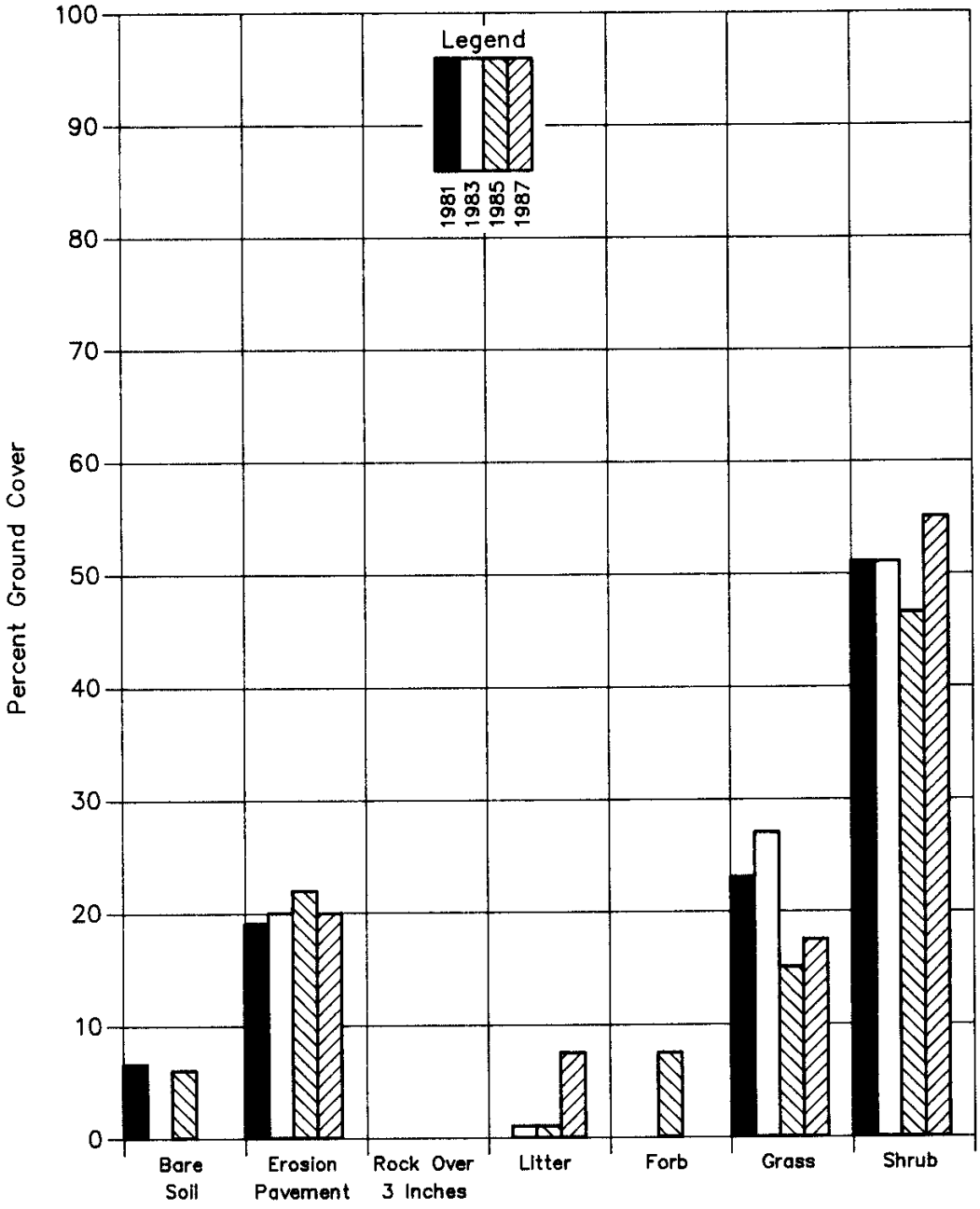

Figure 16. Ground cover composition for the low chamise chaparral trap unit.

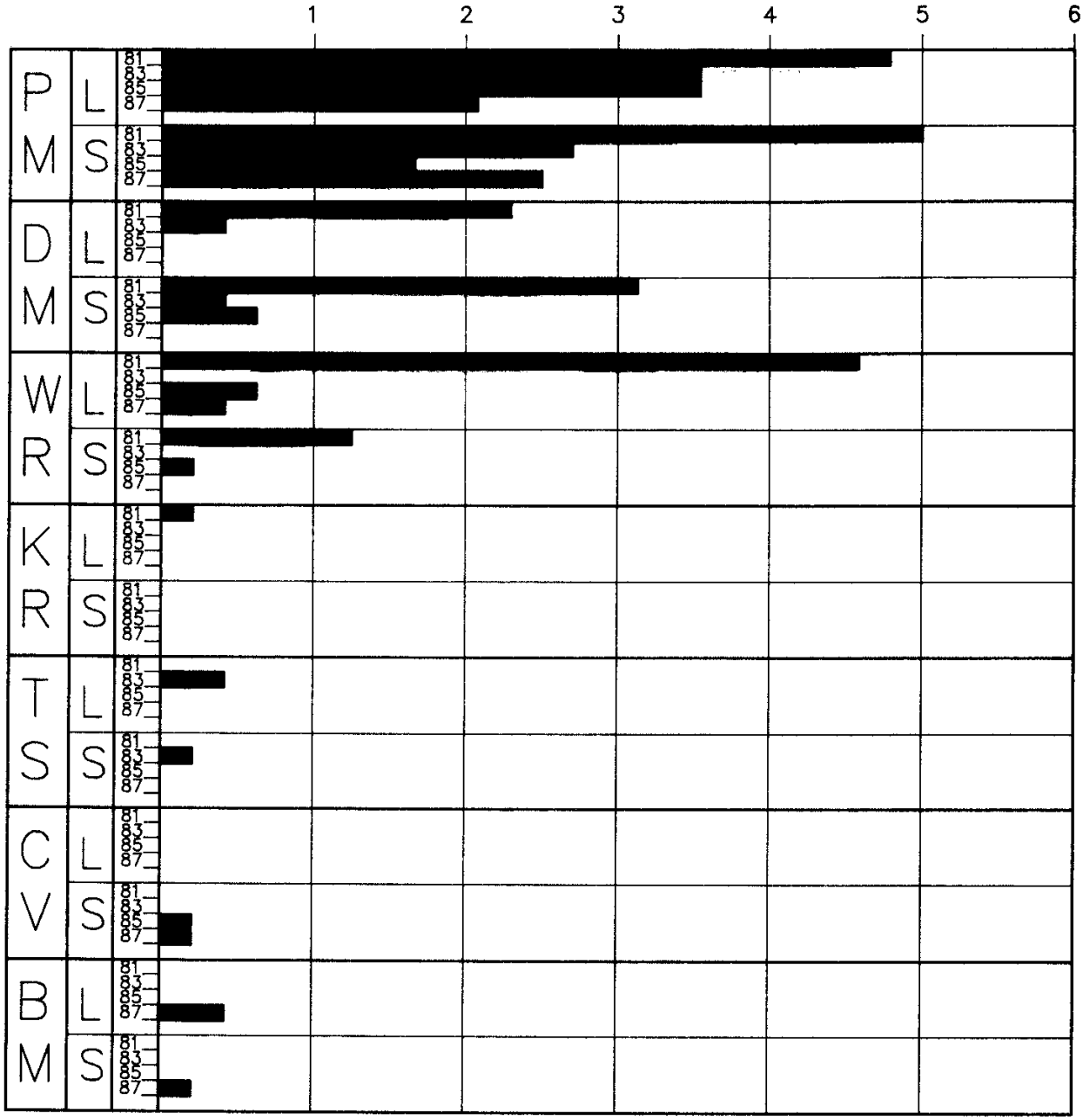

Figure 17. Small mammal catch per 100 trap nights for the low chamise chaparral trap unit (L=live trap, S=snap trap, PM=pinyon mouse, DM=deer mouse, WR=dusky-footed woodrat, KR= kangaroo rat, TS=Trowbridge shrew, CV=California vole, BM= brush mouse).

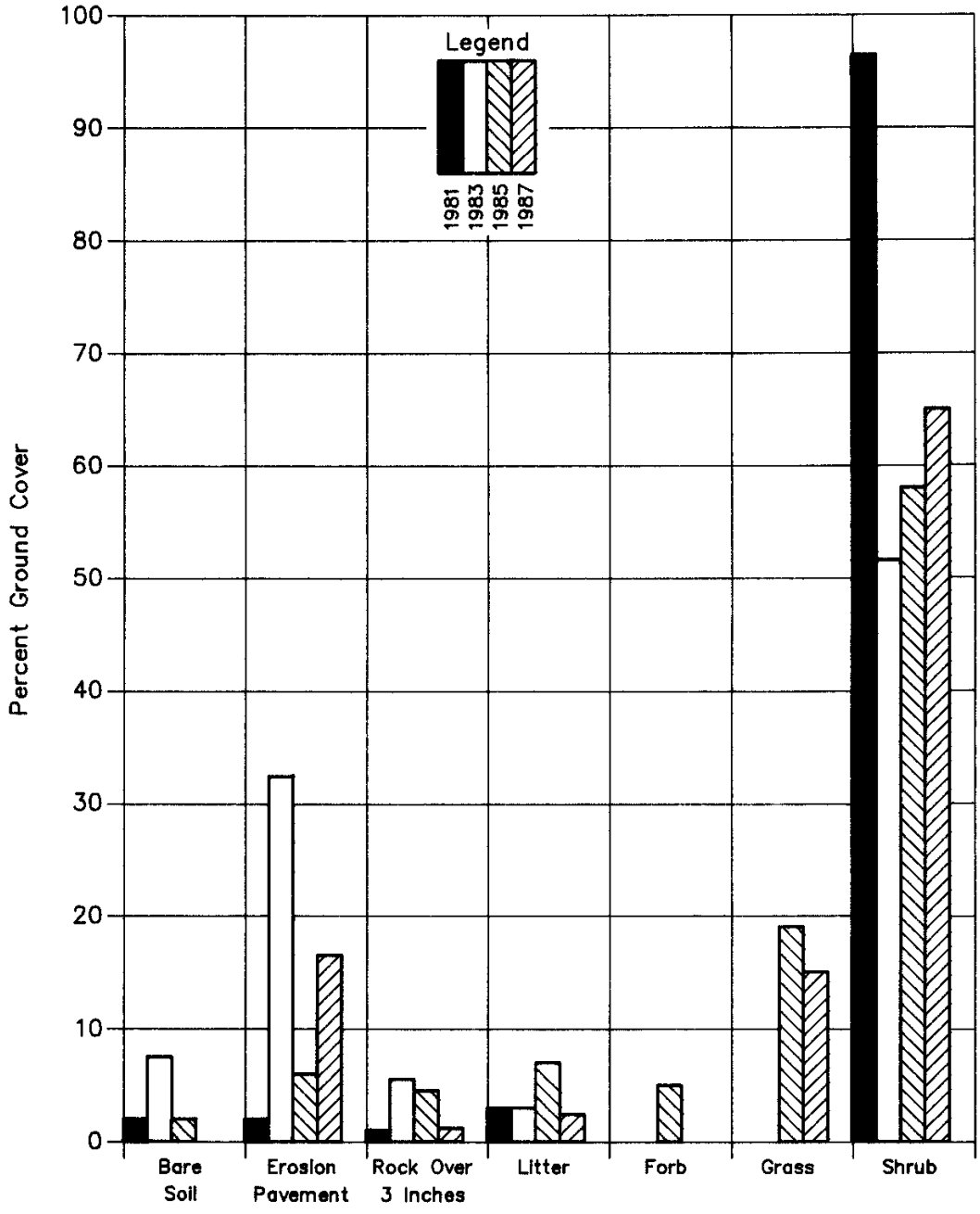

Figure 18. Ground cover composition for the old-growth mixed chaparral trap unit.

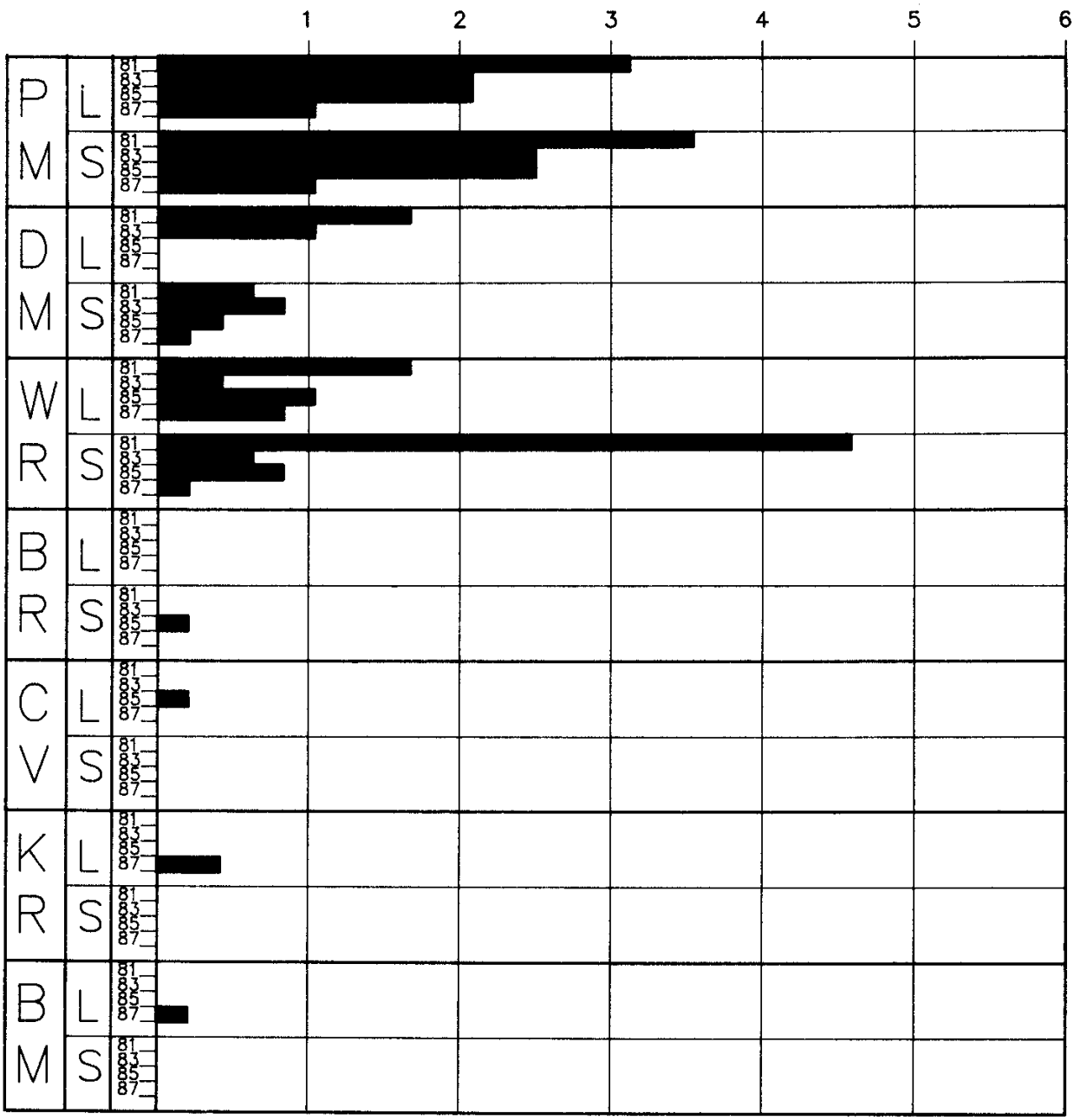

Figure 19. Small mammal catch per 100 trap nights for the old-growth mixed chaparral trap unit (L=live trap, S=snap trap, PM= pinyon mouse, DM=deer mouse, WR=dusky-footed woodrat, BR=brush rabbit, CV=California vole, KR=kangaroo rat, BM= brush mouse).

Deer mouse and woodrat captures have decreased 88 and 79 percent, respectively since 1981. Four small mammal species have benefited from the habitat manipulation caused by the controlled burn. Brush rabbit, California vole, kangaroo rat, and brush mouse were captured in this unit only after the controlled burn.

Effects of Mitigation

The 1982 controlled burn altered the vegetative structure and composition of the area burned. Vegetative response (particularly shrub regrowth) has been slow. Season and intensity of the burn may have temporarily eliminated shrubs from portions of the burn. Resident pre-burn small mammal populations have been adversely affected by burning for the five years following the burn. Species richness has increased as small numbers of California voles and kangaroo rats have become established. Pinyon mouse, deer mouse, brush mouse, brush rabbit, and kangaroo rat populations are all reported to increase in young or intermediate age chaparral (Longhurst 1978). Deer mouse populations in particular are reported to respond favorably to burning (Cook 1959, Lawrence 1966, Wirtz 1977, and Quinn 1979). Total small mammal populations (as indicated by catch/100 trap nights) remain low in comparison to pre-burn levels.

Hydroseeding of grasses and legumes on the powerplant access road fill slopes has provided some small mammal habitat. Pinyon mice and deer mice have been captured on the revegetated fill slopes but only where some form of cover (i.e., rocks, dead and downed woody material) is available.

GRAY SQUIRRELS
(Sciurus griseus)

Introduction

Gray squirrel populations have been adversely affected by geothermal development (Meneghin et al. 1977). Mitigation measures (nest boxes) were developed with the goal of maintaining the gray squirrel population on the Francisco Leasehold at pre-project levels. Population sampling allows assessment of the effectiveness of the mitigation in meeting this goal.

Methods

Time/area counts (15 minutes/165-by-165-foot plot) and capture/recapture techniques were utilized as independent measures of gray squirrel abundance. All gray squirrel sightings during bird population monitoring were recorded. Eighty hours of observation were conducted during 1987 compared to 68, 70, and 78 hours in 1981, 1983, and 1985, respectively. Total gray squirrel sightings were divided by the total number of plot visits to produce an index of abundance.

Trapping with "Tomahawk" single-door live traps (6 by 6 by 19 inches) was conducted for a period of 24 days. One trap was located in each of the 40 black oak study plots (40 traps x 24 days = 960 trap nights). English walnuts were used as bait. Each trap was checked at noon and again at dusk to limit trap shock and subsequent squirrel mortality (Guthrie et al. 1967).

Results and Discussion

Time/area counts indicate a 57-percent decline in the number of squirrels since 1981 (Figure 20). The 1987 time/area count results are approximately 25 percent greater than 1983 results but 35 percent less than the 1985 estimates.

Catch-per-unit effort (new captures only) yielded 0.2 squirrels/100 trap nights in 1987 (Figure 21). The 1987 catch/100 trap nights was 58 percent less than 1981 and 78 percent less than 1985.

The limited gray squirrel captures in 1987 did not allow a population estimate using any capture-recapture method of population estimation. A minimum population size of four squirrels was developed for the 25-acre study area. One male and one nonlactating female were captured during 960 trap nights. One lactating female and one young were observed during nest box checks but eluded capture, resulting in a density of 0.16 squirrels/acre (Figure 22).

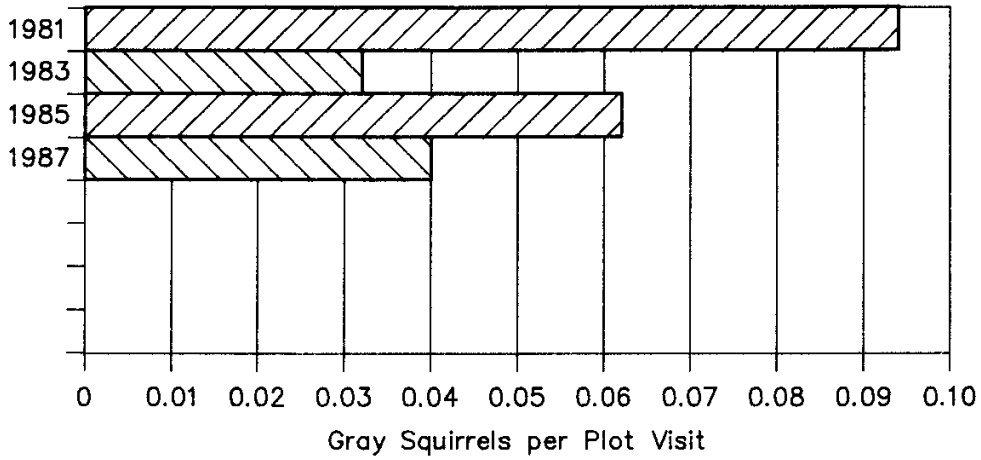

Figure 20. Gray squirrels observed per plot visit.

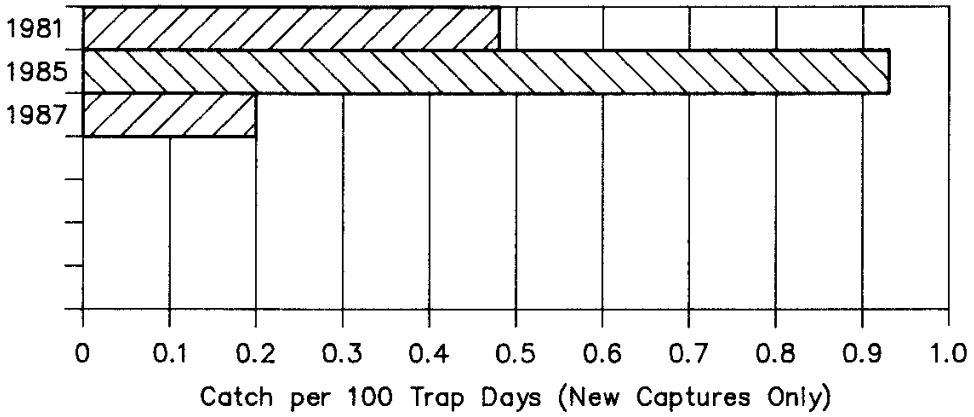

Figure 21. Gray squirrel captures per 100 trap days.

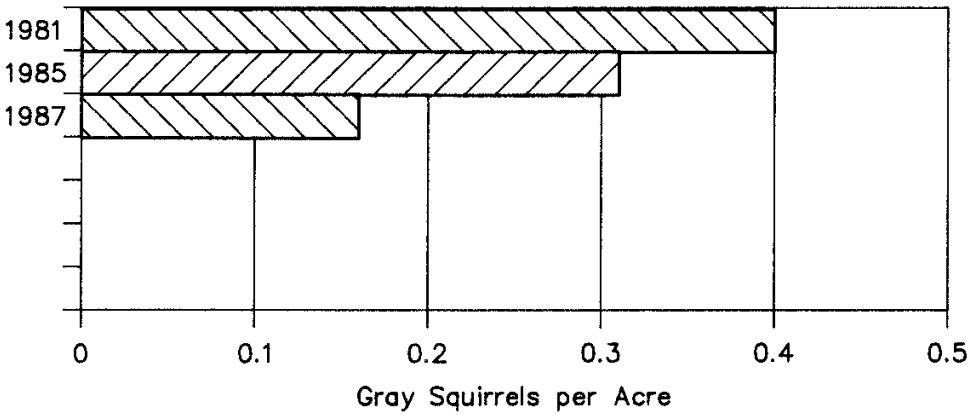

Figure 22. Gray squirrel density estimates from capture–recapture data.

Time/area counts, catch/100 trap nights, and minimum population data all indicate a reduction in the gray squirrel population since 1981. The gray squirrel density within the black oak study area remains considerably less than gray squirrel densities found by Hall (1980) in similar Geysers KGRA habitats.

American kestrels (Falco sparverins) and screech owls (Otus kennicottii) also utilized gray squirrel nest boxes in 1987.

Effects of Mitigation

Fifty gray squirrel nest boxes were installed on the Francisco Leasehold during February 1982. Forty squirrel nest boxes are located within the 12.5-acre portion of the black oak study area (3.2 nest boxes/acre). The remaining ten nest boxes are located between the Francisco and lower Coleman well pads.

Nest box utilization within the study area was zero in 1982, one in 1983, two in 1984, one in 1985, one in 1986, and one in 1987. No squirrel activity has been recorded for any of the ten nest boxes outside of the black oak study area. Twelve young have been produced in the nest boxes over six years. This equates to an annual production rate (nest boxes only) of 0.14 squirrels/acre. Average litter size is two squirrels. Ingles (1965) reports gray squirrel litter sizes as ranging from two to five.

Each nest box is checked for use between April 10 and 27 annually. Each year, vacant nests are discovered within nest boxes which had contained no nest the previous April. These nests may represent early or late breeders which have been missed with once-per-year nest box checks, alternate nest sites that are constructed but not used, alternate nest sites constructed and occupied after and probably because of nest box checks, or nests constructed and used for activities unrelated to reproduction. The gray squirrel breeding season is reported to run from January until May (Ingles 1947), February to July (Asserson 1974), and December to July (Swift 1977, Gilman 1986). The gestation period is approximately 44 days, and young are nursed for approximately 70 days (Ingles 1965). No young of the year have been observed outside of nest boxes before mid-May in the black oak study area, indicating that, if early litters do occur, they are largely unsuccessful. Late nesting may commence after our April nest box examination. Alternate nest sites are constructed and used by eastern gray squirrels (Sciurus carolinensis).

Five eastern gray squirrels moved their litters an average of 4.2 times in a nest box utilization study (Pogge 1981). Many of these moves were believed related to human intrusion (i.e., nest box checks). Both male and female eastern gray squirrels used boxes year round for a variety of activities. Cross (1969) suggests that only female western gray squirrels (pregnant or rearing young) may use cavities. An additional nest box check in late May or early June might be necessary to adequately determine nest box utilization and squirrel production. However, additional disturbance of nesting squirrels may stimulate more litter moves (increased vulnerability of young squirrels) and construction of additional nest sites after the last nest box check.
In summary, it is possible that more reproduction has occurred in nest boxes than has been reported.

MAMMALIAN CARNIVORES

Introduction

Mammalian carnivores were monitored to evaluate how well species richness has been maintained on the leasehold, though no mitigation activities were conducted.

Methods

A 10-by-10-foot track trap is located near the base of the powerplant fill slope in black oak plot 10-1 (Figure 2). The trap consists of a 2-by-4-inch wooden frame filled to a depth of 0.5 inch with fire clay. Canned cat food was used as bait. Mammal visits to the bait are recorded in the soft fire clay and persist for weeks if not removed. All tracks are identified using Murie (1954). Approximately 56 trap nights were conducted in 1987.

In addition to the tracks identified in the track trap, any tracks observed in mud or road dust were identified and recorded. Visual sightings on or adjacent to the leasehold were also recorded.

A predator call was also utilized to detect carnivore presence in 1987.

Results and Discussion

Six mammalian carnivores were present on the leasehold in 1981, but only three mammalian carnivores were determined to be using the leasehold in 1987 (Table 15). Only one species, raccoon (Procyon lotor), was identified in the track trap. The racoon population has apparently benefited from geothermal development. MCR Geothermal personnel have reported more than 14 raccoons observed simultaneously at the Bottle Rock Powerplant dumpster and MCR dumpster. Coyote (Canis latrans) and bobcat (Lynx rufus) tracks were observed elsewhere on the leasehold. No gray fox (Urocyon cinereoargenteus) or spotted skunk (Spilogale putorius) have been observed since 1981. MCR personnel also reported regular bobcat sightings and sporadic ringtail (Bassariscus astutus) sightings during night driving between well pads.

No mammalian carnivores were identified using the predator call. Future studies may employ some mammalian carnivore trapping. Ringtails are difficult to count using a track trap, but are easily captured in a properly baited live trap (Richard Anderson, CEC, pers. comm.).

Table 15. Mammalian carnivore species observed to utilize the Francisco Leasehold.

Scientific Name	Common Name	1981	1983	1985	1987
Procyon lotor	raccoon	X	X	X	X
Mephitis mephitis	striped skunk	X	X		
Spilogale putorius	spotted skunk	X			
Canis latrans	coyote	X	X	X	X
Urocyon cinereoargenteus	gray fox	X			
Lynx rufus	bobcat	X	X	X	X

Effects of Mitigation

No mitigation measures were employed to specifically enhance mammalian carnivore habitat. Those mitigation measures (i.e., guzzlers) which enhance or congregate prey species populations have not maintained mammalian carnivore species richness.

BLACK-TAILED DEER
(Odocoileus hemionus columbianus)

Introduction

Black-tailed deer are an economically important recreational species in Lake County. Mitigation for the deer population was required (DWR 1979).

Methods

Data were collected on the habitat quality (ground cover composition, and shrub age and form classes) and relative abundance of deer (quarterly deer pellet group counts) from 80 circular milliacre plots in the black oak and chaparral study areas. Ground cover composition and shrub species composition data are presented within the vegetation section of this report. Each individual shrub within a milliacre plot was classified into an age and form class (Dasmann 1951). Age classes included seedling or sprout (S), young (Y), mature (M), and decadent (D). Form classes include: (1) all available with little or no hedging, (2) all available but moderately hedged, (3) all available and tightly hedged, (4) largely available with little or no hedging, (5) largely available and moderately hedged, (6) largely available but tightly hedged, (7) mostly unavailable, and (8) unavailable.

Groups of deer fecal pellets were counted from each milliacre plot. After compilation of the pellet groups of each plot, all pellets were removed. Pellet group counts have been conducted quarterly during each year since April 1981. Domestic goats, which produce pellets virtually indistinguishable from those of deer, were not effectively excluded from the leasehold until July 1981, but still occasionally escape confinement and wander on the leasehold.

Results and Discussion

Black Oak Study Area

Deer use within the black oak study area (as indicated by deer pellet group counts) exhibited a sharp decline from 1981 to 1983 and a relatively stable trend since 1983 (Table 16). Deer use has declined approximately 60 percent since the first four quarters (October 1981 through July 1982).

Table 16. Summary of deer days use per acre for the black oak study area.

	January	April	July	October	Mean
1981	-	-	-	71	71
1982	43	41	33	49	42
1983	22	15	9	30	19
1984	10	19	28	26	21
1985	15	12	10	17	14
1987	17	23	23	-	20

Analysis of habitat quality indicated that range quality is good (i.e., seedling and young age classes exceed decadent by at least 5 percent, Dasmann 1981) for all species (Table 17). Browse availability (the proportion of browse species available to deer as forage) has gone from good (1981) to poor (1987) (Table 18). In 1987, 68 percent of the manzanita plants were classified as largely unavailable or unavailable. Decreased browse availability has undoubtedly contributed to the observed decrease in deer use.

Chaparral Study Area

Deer use within the chaparral study area exhibited the same trend as use within the black oak study area (Table 19). Deer use declined from 1981 to 1983 and has remained relatively stable since 1983. Deer use has declined approximately 56 percent since the first four quarters (October 1981 to July 1982).

Table 17. Shrub age class densities for the black oak study area.

Species	Age Class	1981 #/Acre	1981 %	1983 #/Acre	1983 %	1985 #/Acre	1985 %	1987 #/Acre	1987 %
Manzanita	S	225	8.7	-	-	25	1.1	25	0.9
	Y	250	9.7	375	15.6	275	11.8	350	11.9
	M	2,050	79.5	1,775	73.8	1,875	80.6	2,375	81.2
	D	50	1.9	250	10.4	125	5.3	175	5.9
Black oak	S	125	14.7	-	-	-	-	-	-
	Y	425	49.9	625	73.5	575	60.5	425	56.6
	M	175	20.5	50	5.9	150	15.7	50	6.6
	D	125	14.7	175	20.6	225	23.6	275	36.6
Ponderosa pine	S	100	66.6	-	-	-	-	-	-
	Y	25	16.6	50	66.6	50	66.6	50	100.0
	M	25	16.6	25	33.3	25	33.3	-	-
	D	-	-	-	-	-	-	-	-
Douglas fir	S	50	40.0	25	20.0	-	-	-	-
	Y	75	60.0	100	80.0	125	83.6	150	100.0
	M	-	-	-	-	25	16.6	-	-
	D	-	-	-	-	-	-	-	-
Madrone	S	25	50.0	-	-	-	-	-	-
	Y	-	-	50	66.6	25	50.0	50	100.0
	M	25	50.0	25	23.3	25	50.0	-	-
	D	-	-	-	-	-	-	-	-
Deerbrush	S	-	-	-	-	-	-	-	-
	Y	-	-	-	-	-	-	-	-
	M	25	100.0	50	100.0	-	-	-	-
	D	-	-	-	-	25	100.0	25	100.0
Live oak	S	-	-	25	100.0	-	-	-	-
	Y	-	-	-	-	-	-	-	-
	M	-	-	-	-	-	-	-	-
	D	-	-	-	-	-	-	-	-

Table 18. Shrub form class densities for the black oak study area.

Species	Form Class	1981		1983		1985		1987	
		#/Acre	%	#/Acre	%	#/Acre	%	#/Acre	%
Manzanita	1	450	17.1	525	22.8	325	13.9	350	11.9
	2	300	11.4	50	2.2	250	10.8	225	7.7
	3	75	2.9	100	4.4	100	4.3	125	4.3
	4	675	25.7	700	30.4	775	33.3	175	5.9
	5	50	1.9	-	-	25	1.1	50	1.7
	6	25	1.0	-	-	-	-	-	-
	7	1,000	38.0	825	35.8	725	31.1	1,825	62.2
	8	50	1.9	100	4.4	125	5.4	175	5.9
Black oak	4	75	9.1	75	7.9	75	8.1	25	3.3
	7	500	60.6	650	68.4	625	67.5	450	59.9
	8	250	30.3	225	23.7	225	24.3	275	36.6
Ponderosa pine	1	75	75.0	-	-	-	-	25	50.0
	4	-	-	25	33.3	-	-	-	-
	7	25	25.0	50	66.6	75	100.0	25	50.0
Douglas fir	1	700	66.6	50	50.0	75	50.0	50	50.0
	2	25	16.7	-	-	-	-	-	-
	4	-	-	50	50.0	-	-	25	25.0
	7	25	16.7	-	-	75	50.0	25	25.0
Madrone	1	25	50.0	50	66.6	25	50.0	25	50.0
	7	25	50.0	25	33.3	25	50.0	25	50.0
Deerbrush	3	-	-	25	50.0	-	-	-	-
	7	25	100.0	25	50.0	-	-	-	-
	8	-	-	-	-	25	100.0	25	100.0
Live oak	1	-	-	25	100.0	-	-	-	-

Table 19. Summary of deer days use per acre for the chaparral study area.

	January	April	July	October	Mean
1981	-	-	-	92	92
1982	80	91	32	48	63
1983	38	42	27	49	39
1984	40	38	32	37	38
1985	65	39	17	33	39
1987	40	33	23	-	37

Range quality remains good for all species except buckbrush (Ceanothus cuneatus) (Table 20). Approximately 100 percent more buckbrush plants were classified as decadent than young or seedling. All buckbrush reproduction (i.e., seedling and young age classes) was located within the 1982 controlled burn. Buckbrush is considered of fair value as browse for deer (Sampson and Jesperson 1963). The percentage of individuals classified as decadent has increased for chamise, manzanita, buckbrush, and live oak since 1985.

Overall, browse availability was rated as good, with available classes exceeding unavailable classes by more than 5 percent (Table 21). Buckbrush and chaparral pea were the only browse species which are rated poor in availability.

Table 20. Shrub age class densities for the chaparral study area.

Species	Age Class	1981 #/Acre	1981 %	1983 #/Acre	1983 %	1985 #/Acre	1985 %	1987 #/Acre	1987 %
Chamise	S	875	11.2	1,425	14.5	1,275	15.9	1,600	16.8
	Y	1,500	19.1	2,325	23.6	2,425	30.3	1,450	15.2
	M	5,050	64.4	3,450	35.0	4,200	52.5	5,050	52.9
	D	400	5.1	2,625	26.6	75	0.9	1,450	15.2
Manzanita	S	175	8.4	200	10.9	675	27.2	1,025	35.3
	Y	400	19.2	350	19.0	225	9.0	100	3.4
	M	1,325	63.6	875	47.6	1,300	52.0	1,350	46.6
	D	175	8.4	400	21.7	275	11.0	425	14.7
Buckbrush	S	-	-	50	3.1	250	14.7	225	12.0
	Y	200	11.4	-	-	50	2.9	25	1.3
	M	1,325	75.3	1,300	81.1	1,350	78.3	1,025	54.7
	D	225	12.7	250	15.6	50	2.9	500	26.7
Live oak	S	-	-	50	4.2	-	-	125	7.9
	Y	100	12.1	125	10.6	100	9.1	250	15.9
	M	700	84.8	950	80.5	975	87.7	1,050	66.6
	D	25	3.0	50	4.2	25	2.2	150	9.5
Poison oak	S	300	54.5	1,425	94.9	500	100.0	2,475	100.0
	Y	75	13.6	-	-	-	-	-	-
	M	175	31.7	50	4.4	-	-	-	-
	D	-	-	25	1.6	-	-	-	-
Chaparral pea	S	-	-	75	21.4	25	10.0	-	-
	Y	50	25.0	125	35.7	-	-	-	-
	M	125	62.5	125	35.7	225	90.0	200	100.0
	D	25	12.5	25	7.1	-	-	-	-
Digger pine	S	-	-	-	-	-	-	-	-
	Y	-	-	-	-	-	-	-	-
	M	75	100.0	100	100.0	100	100.0	-	-
	D	-	-	-	-	-	-	-	-
Black oak	S	-	-	-	-	-	-	-	---
	Y	-	-	-	-	-	-	-	-
	M	25	100.0	-	-	-	-	-	-
	D	-	-	-	-	-	-	-	-
Lemmon ceanothus	S	-	-	-	-	-	-	-	-
	Y	25	100.0	-	-	25	50.0	-	-
	M	-	-	25	33.3	25	50.0	25	100.0
	D	-	-	-	-	-	-	-	-

Table 20 (cont'd.).

Species	Age Class	1981		1983		1985		1987	
		#/Acre	%	#/Acre	%	#/Acre	%	#/Acre	%
Toyon	S	-	-	-	-	-	-	-	-
	Y	-	-	-	-	-	-	-	-
	M	25	100.0	25	100.0	25	100.0	-	-
	D	-	-	-	-	-	-	25	100.0
Knobcone pine	S	-	-	-	-	-	-	-	-
	Y	25	100.0	-	-	-	-	-	-
	M	-	-	-	-	-	-	-	-
	D	-	-	-	-	-	-	-	-
Deerbrush	S	-	-	-	-	-	-	-	-
	Y	-	-	-	-	-	-	-	-
	M	-	-	-	-	25	100.0	-	-
	D	-	-	-	-	-	-	-	-
Ponderosa pine	S	-	-	-	-	-	-	-	-
	Y	-	-	-	-	-	-	-	-
	M	-	-	-	-	-	-	25	100.0
	D	-	-	-	-	-	-	-	-

Table 21. Shrub form class densities for the chaparral study area.

Species	Form Class	1981		1983		1985		1987	
		#/Acre	%	#/Acre	%	#/Acre	%	#/Acre	%
Chamise	1	3,075	38.5	2,825	30.4	1,825	20.7	4,550	47.6
	2	2,625	32.8	2,500	26.9	1,950	22.2	1,700	17.8
	3	475	5.9	975	10.4	3,500	39.8	650	6.8
	4	1,000	12.5	525	5.6	325	3.7	500	5.2
	5	300	3.7	75	0.8	50	0.6	125	1.3
	6	-	-	-	-	-	-	25	0.3
	7	125	1.5	225	2.4	250	2.8	550	5.7
	8	275	4.6	2,150	23.1	875	9.9	1,450	15.1
Manzanita	1	525	26.9	350	18.9	925	37.3	950	32.7
	2	125	6.4	200	10.8	275	11.1	225	7.8
	3	25	2.5	125	6.8	125	5.1	50	1.7
	4	275	14.1	225	12.2	300	12.1	350	12.0
	5	-	-	-	-	-	-	75	2.6
	6	-	-	-	-	-	-	25	0.9
	7	750	38.4	550	29.7	550	22.2	800	27.5
	8	225	11.5	400	21.6	300	12.1	425	14.7
Buckbrush	1	-	-	100	6.3	400	23.5	175	9.9
	2	50	3.1	250	15.6	200	11.8	250	14.0
	3	300	18.4	200	12.4	175	10.3	175	9.9
	4	400	24.5	200	12.4	250	14.7	50	2.8
	5	200	12.2	125	7.8	150	8.8	75	4.2
	6	100	6.1	25	1.6	-	-	75	4.2
	7	325	19.9	450	28.0	425	24.9	475	26.7
	8	250	15.3	250	15.6	100	5.8	500	28.1
Live oak	1	50	6.1	200	16.0	50	3.3	275	17.5
	2	-	-	75	6.0	50	3.3	150	9.5
	3	100	12.2	200	16.0	275	18.3	200	12.6
	4	250	30.3	200	16.0	475	31.6	100	6.3
	5	100	12.2	50	4.0	75	4.9	25	1.6
	6	50	6.1	-	-	50	3.3	25	1.6
	7	250	30.3	450	36.0	525	34.9	650	41.3
	8	25	3.0	75	3.0	-	-	150	9.5
Poison oak	1	550	100.0	1,400	98.2	3,650	100.0	2,475	100.0
	2	-	-	25	1.8	-	-	-	-
Deerbrush	4	-	-	-	-	25	100.0	-	-
Black oak	7	25	100.0	-	-	-	-	-	-

Table 21 (cont'd.).

Species	Form Class	1981 #/Acre	1981 %	1983 #/Acre	1983 %	1985 #/Acre	1985 %	1987 #/Acre	1987 %
Chaparral pea	1	25	12.5	-	100.0	75	28.5	-	-
	2	100	50.0	75	21.4	-	-	-	-
	3	-	-	-	-	75	30.0	-	-
	4	50	25.0	-	-	-	-	75	37.5
	5	-	-	50	14.3	-	-	25	12.5
	6	-	-	-	-	-	-	-	-
	7	-	-	75	21.4	100	40.0	100	50.0
	8	25	12.5	50	14.3	-	-	-	-
Knobcone pine	7	25	100.0	-	-	-	-	-	-
	8	-	-	25	100.0	-	-	-	-
Lemmon ceanothus	1	25	100.0	-	-	25	50.0	-	-
	3	-	-	25	33.3	25	50.0	25	100.0
	8	-	-	50	66.6	-	-	-	-
Digger pine	7	50	66.6	75	100.0	100	100.0	-	-
	8	25	33.3	-	-	-	-	-	-
Toyon	4	25	100.0	-	-	25	100.0	-	-
	7	-	-	25	100.0	-	-	-	-
	8	-	-	-	-	-	-	25	100.0
Ponderosa pine	7	-	-	-	-	-	-	25	100.0

Effects of Mitigation

The controlled burning of five acres of chaparral habitat in 1982 has not maintained deer use at pre-project levels within the chaparral study area. Controlled burning increases availability and nutritional content of browse species. With adequate cover, the carrying capacity of burned chaparral is approximately four times as great as mature chaparral (Biswell 1961). These data suggest that some factor or factors other than forage quantity and quality are limiting deer use of the chaparral study area.

SUMMARY OF THE EFFECTIVENESS OF MITIGATION

The Department of Water Resources' Bottle Rock Wildlife Mitigation and Monitoring Program is required by the California Energy Commission (CEC) and was designed in coordination with the CEC, the Department of Fish and Game, the Energy Division of DWR, and Dr. Phillip Leitner, a biological resources consultant. The monitoring program was designed with two purposes. First, the program allows an assessment of the effectiveness of the required mitigation to maintain avian secondary cavity nesters, quail, mourning doves, gray squirrels, and black-tailed deer at or above pre-project population levels. Second, the program monitors those wildlife species not subject to mitigation to insure that unprojected adverse impacts do not adversely affect species richness on the leasehold.

Nest box utilization by avian secondary cavity nesters totalled 16 percent in 1982, 34 percent in 1983, 46 percent in 1984, 76 percent in 1985, and 40 percent in 1987. Seven avian species have utilized bird boxes on the leasehold. These include house wren, plain titmouse, white-breasted nuthatch, ash-throated flycatcher, violet-green swallow, tree swallow, and western bluebird. Since installation of the nest boxes in 1982, the 12.5 acres containing nest boxes have supported a significantly higher density of secondary cavity nesters than the 12.5-acre control. Total density of secondary cavity nesters has increased as much as 600 percent on the 12.5-acre area containing nest boxes, following installation of the boxes. Nest boxes appear to be supplementing natural cavities and have increased the density of secondary cavity nesters well above pre-project levels.

California quail and mountain quail populations have fluctuated drastically from year to year, following installation of the two 750-gallon guzzlers. Water currently does not appear to be a limiting factor to quail populations on the Francisco Leasehold. Observations indicate minimal use of guzzlers by quail during June through September.

None of the 50 dove cones have been utilized by any species in the six years since their installation. Mourning dove population has remained relatively stable (except in 1985) since the baseline study. Mourning dove densities were approximately 10 times as high within the burned portion of the chaparral study area as in the unburned portion during 1987. Increased seed availability within the burn undoubtedly contributed to the higher densities recorded.

The gray squirrel population has declined from 57 to 60 percent since 1981. Nest boxes have been used by at least one nesting gray squirrel every year since 1982. Two litters were raised in nest boxes during 1984. Twelve young have been reared in nest boxes. This equates to an annual production (nest boxes only) of 0.14 squirrel/acre in the area containing nest boxes. Nest boxes appear to be readily accepted by the nesting females of the gray squirrel population. Nest box utilization remains low in comparison to the number of available boxes but high in relation to the population size. Screech owls and American kestrels are among the species which have accepted and used squirrel nest boxes.

Controlled burning of five acres of chaparral habitat has not maintained the black-tailed deer population at pre-project levels. Browse availability and nutritional content increased following chaparral fire. Apparently, some factor other than forage quality and quantity is limiting local deer populations.

Species richness of both plants and animals is being maintained on the leasehold.

REFERENCES

Abrams, L. 1951. Illustrated flora of the Pacific states: Washington, Oregon, and California. Stanford Univ. Press, Stanford, Calif.

Anderson, S. H. 1970. Forest birds of western Oregon. Ph.D. thesis, Oregon State Univ., Corvallis, Ore.

Asserson, W. C. 1974. Western gray squirrel study in Kern County, California. Calif. Fish and Game, Wildl. Manage. Branch Admin. Rept. No. 74-1.

Biswell, H. H., R. D. Taber, D. W. Hendrick, and A. M. Schultz. 1952. Management of chamise brushlands for game in the North Coast region of California. Calif. Fish and Game 38(4):453-484.

_____. 1961. Manipulation of chamise brush for deer range improvement. Calif. Fish and Game 47(2):125-144.

Bond, R. R. 1957. Ecological distribution of breeding birds in upland forests of southern Wisconsin. Ecol. Monographs 27:351-384.

Brown, J. D., and R. P. Balda. 1983. Use of nest boxes in ponderosa pine forests. In (J. W. Davis, ed.) Snag habitat management. Proceedings of the Symposium, pp. 180-187. Flagstaff, Ariz. Rocky Mountain Range and Experiment Station, U. S. Dept. Agri., Forest Service Gen. Tech. Rept. RM-99.

Burt, W. H., and R. P. Grossenheider. 1964. A field guide to the mammals. 3rd edition. Houghton-Mifflin Co., Boston, Mass.

Cook, S. F., Jr. 1959. The effects of fire on a population of small mammals. Ecol. 40(1):102-108.

Cross, S. P. 1969. Behavioral aspects of western gray squirrel ecology. Ph.D. thesis. Univ. Arizona, Tucson, Ariz.

Dasmann, W. P. 1951. Some deer range survey methods. Calif. Fish and Game 37(1):43-52.

_____. 1981. Deer range improvement and management. McFarland and Co., Inc., London, England.

Department of Water Resources. 1979. Bottle Rock Powerplant Application for Certification. State of California, Sacramento, Calif.

_____. 1981. Bottle Rock biological resources baseline report. State of California.

_____. 1984. Bottle Rock Geothermal Powerplant biological resources mitigation and monitoring biennial report. State of California.

_____. 1986. Bottle Rock Geothermal Powerplant biological resources mitigation and monitoring biennial report. State of California.

Gilman, K. N. 1986. The western gray squirrel (Sciurus griseus), its summer home range, activity times, and habitat usage in northern California. Master's thesis, Calif. State Univ., Sacramento, Calif.

Guthrie, D. R., J. C. Osborne, and H. S. Mosby. 1967. Physiological changes associated with shock in confined gray squirrels. Journ. Wildl. Manage. 31(1):102-108.

Hall, D. J. 1980. Geysers wildlife investigations, western gray squirrel. Pacific Gas and Elec. Co., Dept. Eng. Res., Rept. 420-79.132, San Ramon, Calif.

Holmes, R. T., and S. K. Robinson. 1981. Tree species preference of foraging insectivores birds in a northern hardwood forest. Oecologia 48:31-33.

Houck, J. W. 1979. California wildlife/habitat relationships program, north coast/Cascades zone. Vol. I, Herp Narratives. U. S. Dept. Agri., Forest Service Misc. Publ. 109 pp.

Ingles, L. G. 1947. Ecology and life history of the California gray squirrel. Calif. Fish and Game 33(3):139-159.

_____. 1965. Mammals of the Pacific states: California, Oregon, and Washington. Stanford Univ. Press, Stanford, Calif.

Kenga, E. E. 1961. Some insect parasites associated with the eastern bluebird in Michigan. Bird-Banding 32:91-94.

Karr, J. R., and R. R. Roth. 1971. Vegetation structure and avian density in several new world areas. Am. Nat. 105:423-435.

Lawrence, G. E. 1966. Ecology of vertebrate animals in relation to chaparral fire in the Sierra Nevada foothills. Ecol. 47:278-291.

Lillywhite, H. B., and F. North. 1974. Perching behavior of Sceloporus occidentalis in recently burned chaparral. Copeia (1974):256-257.

_____. 1977. Effects of chaparral conversion on small vertebrates in Southern California chaparral. Biol. Conserv. 11:171-184.

Linsdale, J. M., and L. P. Tevis, Jr. 1951. The dusky-footed woodrat. Univ. Calif. Press, Berkeley, Calif.

Longhurst, W. M. 1978. Response of bird and mammal populations to fire in chaparral. Calif. Agric. 32(10):9-12.

MacArthur, R. H., and J. W. MacArthur. 1961. On bird species diversity. Ecol. 42:594-598.

Munz, P. A., and D. O. Keck. 1973. A California flora. Univ. Calif. Press, Berkeley, Calif. 1,681 pp.

Murie, O. J. 1954. A field guide to animal tracks. Houghton-Mifflin Co., Boston, Mass.

Neilson, J. A. 1981. Flora of the Mayacmas Mountains. Calif. Energy Commission, Consultant Report P700-81-016.

Peterson, R. T. 1961. A field guide to western birds: Field marks of all species found in North America west of the 100th meridian, with a section on the birds of the Hawaiian Islands. 2nd edition. Houghton-Mifflin Co., Boston, Mass.

Pinkowski, B. C. 1977. Blowfly parasitism of eastern bluebirds in natural and artificial nest sites. J. Wildl. Manage. 41:272-276.

Pogge, F. P. 1981. Squirrel den exposure and multiple den use. Final report, Study F.S.-N.E.-1702-18. Unpubl. report. U. S. Dept. Agri., Forest Service Sci. Lab., Morgantown, W. Virginia.

Quinn, R. 1979. Effects of fire on small mammals in chaparral. 1979 Cal.-Nev. Wildl. Conf. pp. 125-137.

Robbins, C. S., B. Bruun, S. Zim, and A. Singer. 1983. A guide to field identification of North American birds. Golden Press, New York.

Robinson, S. K., and R. T. Holmes. 1984. Effects of plant species and foliage structure on the foraging behavior of forest birds. Auk 101:672-684.

Roth, R. R. 1976. Spatial heterogeniety and bird species diversity. Ecol. 57:773-782.

Sampson, A. W., and B. S. Jesperson. 1963. California range brushlands and browse plants. Univ. Calif. Agri. Exp. Station Manual 33.

Stebbins, R. C. 1954. Amphibians and reptiles of western North America. McGraw Hill, New York.

Sweeney, J. R. 1956. Responses of vegetation to fire, a study of the herbaceous vegetation following chaparral fires. Univ. Calif. Press, Berkeley, Calif.

Swift, R. J. 1977. The reproductive cycle of the western gray squirrel in Butte County, California. Unpubl. master's thesis, Calif. State, Univ., Chico, Calif.

Van Camp, L. E., and C. F. Henry. 1975. The screech owl: it's life history and population ecology in northern Ohio. No. Amer. Fauna 71:1-65.

Wilson, M. F. 1970. Foraging behavior of some winter birds in deciduous woods. Condor 72:169-174.

Wirtz, W. O., Jr. 1977. Vertebrate post-fire succession, p. 46-57. In: H. A. Mooney and C. E. Conrad (eds.), Proceedings of the symposium on the environmental consequences of fire and fuel management in Mediterranean ecosystems. U. S. Dept. Agri., Forest Service, Gen. Tech. Rept. WO-3, Washington, D. C.

Appendix A-1. Combined 1981, 1983, 1985, and 1987 grass and forb species list (scientific names from Munz and Keck 1973 and common names from Abrams 1951).

Scientific Name	Common Name
Amaryllidaceae	
Allium amplectens	narrow-leaved onion
A. bolanderi	Bolander's onion
Brodiaea sp.	brodiaea
B. californica	California brodiaea
B. congesta	northern saitas
B. hyacinthina	wild hyacinth
B. laxa	common triteleia
B. minor	small brodiaea
B. pulchella	blue dicks
Asclepiadaceae	
Asclepias sp.	milkweed
Boraginaceae	
Amsinckia sp.	fiddle-neck
Cryptantha muricata	prickly cryptantha
Cynoglossum grande	grand hound's tongue
Pectocarya pusilla	
Plagiobothrys sp.	popcorn flower or allocarya
P. bracteatus	bracted allocarya
Campanulaceae	
Githopsis diffusa	southern blue-cup
Githopsis specularioides	
Caryophyllaceae	
Arenaria douglasii	Douglas' sandwort
Cerastium viscosum	mouse-eared chickweed
Kohlrauschia velutina	grass pink
Saponaria officinalis	bouncing bet
Silene californica	California Indian pink
S. gallica	common catchfly
Stellaria media	common chickweed
Compositae	
Achillea borealis	common yarrow
Achyrachaena mollis	blow-wives
Agoseris sp.	mountain dandelion
Agoseris heterophylla	annual agoseris
Carduus pycnocephalus	Italian thistle
Centaurea sp.	star thistle
C. cyanus	bachelor's button
Cirsium vulgare	bull thistle
Eriophyllum lanatum	common woolly sunflower
Helianthus sp.	sunflower
Hieracium albiflorum	hawkweed

Appendix A-1 (cont'd.).

Scientific Name	Common Name
Hypochoeris glabra	smooth cat's-ear
Lasthenia chrysostoma	valley goldfields
Madia sp.	madia
M. anomala	plump-seeded madia
M. elegans	common madia
M. minima	hemizonella
Malacothrix floccifera	woolly malacothrix
Matricaria matricarioides	pineapple weed
Micropus californicus	slender cottonweed
Psilocarphus tenellus	slender woolly-heads
Senecio aronicoides	California butterweed
Taraxacum sp.	dandelion
Wyethia angustifolia	narrow-leaved mule-ears
W. glabra	mule-ears
Convolvulaceae	
Convolvulus collinus	morning-glory
C. subacaulis	hill morning-glory
Crassulaceae	
Dudleya sp.	dudleya
Cruciferae	
Barbarea orthoceras	winter cress
Capsella bursa-pastoris	shepherd's purse
Cardamine oligosperma	few-seeded bitter-cress
Dentaria sp.	toothwort
Draba verna	vernal whitlow-grass
Raphanus sativus	wild radish
Thysanocarpus curvipes	hairy fringe pod
T. radians	ribbed fringe pod
Equisetaceae	
Equisetum hymale	western scouring-rush
Geraniaceae	
Erodium botrys	long-beaked filaree
E. cicutarium	red-stemmed filaree
E. moschatum	white-stemmed filaree
Geranium dissectum	cut-leaved geranium
G. molle	dove's-foot geranium
Gramineae	
Aira caryophyllea	silvery hair-grass
Anthoxanthum odoratum	sweet vernal grass
Briza maxima	large quaking-grass
B. minor	small quaking-grass
Bromus sp.	brome-grass
B. diandrus	ripgut-grass
B. laevipes	woodland brome-grass

Appendix A-1 (cont'd.).

Scientific Name	Common Name
B. mollis	soft cheat
B. rubens	foxtail brome-grass
B. tectorum	downy brome-grass
Cynosurus sp.	dog's-tail grass
Dactylis glomerta	orchard grass
Elymus sp.	rye-grass
Elymus glaucus	blue rye grass
Festuca rubra	red fescue
Gastridium ventricosum	nitgrass
Hordeum sp.	barley
Lolium sp.	rye-grass
L. multiflorum	Australian rye-grass
L. perenne	English rye-grass
Melica sp.	melic
Melica californica	western melica
Poa sp.	bluegrass
P. pratensis	Kentucky bluegrass
P. scabrella	Malpais bluegrass
Sitanion sp.	squirrel-tail
Stipa sp.	stipa
Taeniatherum sp.	medusa head
Taeniatherum asperum	medusa head
Vulpia sp.	fescue
V. bromoides	six-weeks fescue
V. microstachys	Nuttall's fescue
V. myuros	rattail fescue
Hepaticae	liverwort
Hydrophyllaceae	
Emmenanthe penduliflora	whispering bells
Nemophila menziesii	baby blue-eyes
N. parviflora	small-flowered nemophila
Hypericaceae	
Hypericum concinnum	gold wire
Iridaceae	
Iris macrosiphon	bowl-tubed iris
Sisyrinchium bellum	California blue-eyed grass
Juncaceae	
Juncus sp.	rush
Luzula comosa	common wood-rush
Labiatae	
Marrubium vulgare	common hoarhound
Mentha pulegium	pennyroyal
Monardella sp.	monardella
Scutellaria tuberosa	Dannie's skullcap
Stachys rigida	rigid hedge nettle

Appendix A-1 (cont'd.).

Scientific Name	Common Name
Leguminosae	
Astragalus sp.	locoweed
A. gambellianus	Gambell's dwarf locoweed
Lathyrus sulphureus	snub pea
Lotus corniculatus	bird's-foot trefoil
L. crassifolius	broad-leaved hosackia
L. humistratus	short-podded hosackia
L. micranthus	small-flowered hosackia
L. pinnatus	pinnate-leaved hosackia
Lupinus bicolor	Lindley's annual lupine
L. formosus	summer lupine
L. latifolius	broad-leaved lupine
L. vallicola	Douglas' annual lupine
Melilotus indica	Indian melilot
Trifolium sp.	clover
Trifolium microdon	clover
T. bifidum	notch-leaved clover
T. cyathiferum	bowl clover
T. dichotomum	branched Indian clover
T. gracilentum	pin-point clover
T. hirtum	clover
T. incarnatum	French or Italian clover
T. microcephalum	small-headed clover
T. repens	white clover
T. tridentatum	tomcat clover
Vicia americana	American vetch
V. californicus	California vetch
V. sativa	spring vetch
Liliaceae	
Calochortus amabilis	golden fairy lantern
C. nudus	naked star tulip
C. tolmiei	Tolmie's star tulip
Fritillaria lanceolata	purple rice-bulbed fritillaria
Malvaceae	
Sidalcea diploscypha	fringed sidalcea
Onagraceae	
Cammisonia graciliflora	slender-flowered primrose
C. micrantha	small primrose
Clarkia gracilis	farewell-to-spring
C. purpurea	purple godetia
Epilobium minutum	minute willow-herb
Papaveraceae	
Eschscholzia californica	California poppy

Appendix A-1 (cont'd.).

Scientific Name	Common Name
Plantaginaceae	
Plantago erecta	California plantain
P. lanceolata	English plantain
Polemoniaceae	
Collomia heterophylla	varied-leaved collomia
Gilia capitata	blue-field gilia
Linanthus acicularis	bristly linanthus
L. bicolor	bicolored linanthus
L. serrulatus	Madera linanthus
Microsteris gracilis	slender phlox
Navarretia sp.	navarretia
Polygonaceae	
Rumex sp.	dock
Portulacaceae	
Montia gypsophiloides	coast range montia
M. perfoliata	miner's lettuce
Primulaceae	
Anagallis arvensis	scarlet pimpernel
Dodecatheon hendersonii	Henderson's shooting star
Pteridaceae	
Pityrogramma triangularis	gold fern
Pteridium aquilinum	western bracken
Ranunculaceae	
Delphinium hesperium	western larkspur
D. nudicaule	red larkspur
Ranunculus occidentalis	western buttercup
Rosaceae	
Potentilla sp.	cinquefoil
Rubiaceae	
Galium aparine	goose grass
G. nuttallii	climbing bedstraw
Sherardia arvensis	blue field madder
Saxifragaceae	
Lithophragma affinis	woodland star
Scrophulariaceae	
Castilleja sp.	Indian paint-brush
Collinsia grandiflora	large-flowered blue-eyed mary
C. parviflora	small-flowered blue-eyed mary
Mimulus angustatus	narrow-leaved pansy monkey-flower

Appendix A-1 (cont'd.).

Scientific Name	Common Name
M. guttatus	common large monkey-flower
M. kelloggii	Kellogg's monkey-flower
M. nasutus	snouted monkey-flower
M. pilosus	downy mimetanthe
M. tricolor	tricolor monkey flower
Orthocarpus attenuatus	narrow-leaved orthocarpus
O. erianthus	Johnny tuck
O. lithospermoides	cream sacs
Pedicularis densiflora	Indian warrior
Penstemon heterophyllus	foothill penstemon
Verbascum sp.	mullein
Veronica persica	Persian speedwell
Selaginellaceae	
Selaginella hanseni	Hansen's selaginella
Solanaceae	
Nicotiana bigelovii	Indian tobacco
Umbelliferae	
Anthriscus scandicina	bur chervil
Apiastrum angustifolium	wild celery
Lomatium sp.	lomatium
Osmorhiza chilensis	mountain sweet-cicely
Sanicula bipinnatifida	purple sanicle
S. crassicaulis	pacific sanicle
Scandix pecten-veneris	shepherd's needle
Torilis nodosa	knotted hedge-parsley
Valerianaceae	
Plectritis sp.	plectritis
Verbenaceae	
Verbena sp.	vervain
Violaceae	
Viola lobata	yellow wood violet
V. pedunculata	California golden violet

Appendix A-2. Combined 1981, 1983, 1985, and 1987 tree and shrub species list.

Scientific Name	Common Name
Anacardiaceae	
Rhus trilobata	squaw bush
Toxicodendron diversilobum	poison oak
Ericacease	
Arbutus menziesii	madrone
Arctostaphylos glandulosa	Eastwood's manzanita
A. manzanita	big manzanita
Fagaceae	
Quercus chrysolepis	canyon live oak
Q. dumosa	California scrub oak
Q. kelloggii	California black oak
Q. lobata	valley white oak
Q. wislizenii	shrub interior live oak
Garryaceae	
Garrya fremontii	Fremont's silk-tassel
Oleaceae	
Fraxinus latifolia	Oregon Ash
Hydrophyllaceae	
Eriodictyon californica	yerba santa
Lauraceae	
Umbellularia californicum	California bay
Leguminosae	
Pickeringia montana	chaparral pea
Robinia pseudo-acacia	locust
Pinaceae	
Pinus attenuata	knobcone pine
P. lambertiana	sugar pine
P. ponderosa	ponderosa pine
P. sabiniana	digger pine
Pseudotsuga menziesii	Douglas fir
Rhamnaceae	
Ceanothus cuneatus	wedgeleaf ceanothus
C. integerrimus	deerbrush ceanothus
C. jepsonii	Jepson's ceanothus
C. lemmonii	Lemmon ceanothus
Rhamnus crocea	hollyleaf redberry

Appendix A-2 (cont'd.).

Scientific Name	Common Name
Rosaceae	
Adenostoma fasciculatum	chamise
Cercocarpus betuloides	western mountain mahogany
Heteromeles arbutifolia	toyon
Malus sylvestris	common apple
Salicaceae	
Salix sp.	willow
Solanaceae	
Solanum parishii	Parish's nightshade
Taxaceae	
Torreya californica	California nutmeg

Appendix B. Bird species list of the Francisco Leasehold.

Scientific Name	Common Name
Anseriformes	
Anatidae	
Anas platyrhynchos	mallard
Apodiformes	
Apodidae	
Chaetura vauxi	Vaux's swift
Trochilidae	
Archilochus alexandri	black-chinned hummingbird
Calypte anna	Anna's hummingbird
Selasphorus sasin	Allen's hummingbird
Stellula calliope	calliope hummingbird
Charadriformes	
Charadriidae	
Charadrius vociferus	killdeer
Ciconiiformes	
Ardeidae	
Butorides striatus	green heron
Columbiformes	
Columbidae	
Columba fasciata	band-tailed pigeon
Zenaida macroura	mourning dove
Falconiformes	
Accipitridae	
Accipiter cooperii	Cooper's hawk
A. striatus	sharp-shinned hawk
Buteo jamaicensis	red-tailed hawk
Cathartidae	
Cathartes aura	turkey vulture
Falconidae	
Falco sparverius	American kestrel
Galliformes	
Phasianidae	
Callipepla californica	California quail
Oreortyx pictus	mountain quail
Passeriformes	
Aegithalidae	
Psaltriparus minimus	bushtit
Bombycillidae	
Bombycilla cedrorum	cedar waxwing
Certhiidae	
Certhia americana	brown creeper

Appendix B (cont'd.).

Scientific Name	Common Name
Corvidae	
Aphelocoma coerulescens	scrub jay
Corvus brachyrhynchos	common crow
C. corax	common raven
Cyanocitta stelleri	Stellar's jay
Emberizidae	
Icterinae	
Agelaius phoeniceus	red-winged blackbird
Euphagus cyanocephalus	Brewer's blackbird
Icterus galbula bullockii	northern oriole
Molothrus ater	brown-headed cowbird
Xanthocephalus xanthocephalus	yellow-headed blackbird
Emberizinae	
Amphispiza belli	sage sparrow
Cardeulis lawrencei	Lawrence's goldfinch
C. pinus	pine sisken
C. psaltria	lesser goldfinch
C. tristis	American goldfinch
Carpodacus cassinii	Cassin's finch
C. mexicanus	house finch
C. purpureus	purple finch
Chondestes grammacus	lark sparrow
Coecothaustes vespertinus	evening grosbeak
Junco hyemalis oreganus	dark-eyed junco
Loxia curvirostra	red crossbill
Melospiza melodia	song sparrow
Passerculus sandwichensis	savannah sparrow
Passerella iliaca	fox sparrow
Passerina amoena	lazuli bunting
Pheucticus melanocephalus	black-headed grosbeak
Pipilo erythrophthalmus	rufous-sided towhee
P. fuscus	brown towhee
Spizella passerina	chipping sparrow
Zonotrichia atricapilla	golden-crowned sparrow
Z. leucophrys	white-crowned sparrow
Thraupinae	
Piranga ladoviciana	western tanager
Hirundinidae	
Hirundo pyrrhonota	cliff swallow
H. rustica	barn swallow
Progne subis	purple martin
Stelgidopteryx serripennis	northern rough-winged swallow
Tachycineta bicolor	tree swallow
T. thalassina	violet-green swallow
Mimidae	
Mimus polyglottos	northern mockingbird
Toxostoma redivivum	California thrasher
Muscicapidae	
Chamaea fasciata	wrentit

Appendix B (cont'd.).

Scientific Name	Common Name
Sylviinae	
Polioptila caerulea	blue-gray gnatcatcher
Regulus calendula	ruby-crowned kinglet
Turdinae	
Catharus guttatus	hermit thrush
Ixoreus naevins	varied thrush
Sialia mexicana	western bluebird
Turdus migratorius	American robin
Paridae	
Parus inornatus	plain titmouse
P. rufescens	chestnut-backed chickadee
Passeridae	
Passer domesticus	house sparrow
Sittidae	
Sitta carolinensis	white-breasted nuthatch
S. pygmaea	pygmy nuthatch
Sturnidae	
Sturnus vulgaris	starling
Troglodytidae	
Thryomanes bewickii	Bewick's wren
Troglodytes aedon	house wren
Tyrannidae	
Empidonax sp.	Empidonax flycatchers
Myiarchus cinerascens	ash-throated flycatcher
Sayornis nigricans	black phoebe
Tyrannus verticalis	western kingbird
Vireonidae	
Vireo gilvus	warbling vireo
V. huttoni	Hutton's vireo
V. solitarius	solitary vireo
Parulinae	
Dendroica coronata	yellow-rumped warbler
D. nigescens	black-throated gray warbler
D. petechia	yellow warbler
Vermivora celata	orange-crowned warbler
V. ruficapilla	Nashville warbler
Wilsonia pusilla	Wilson's warbler
Piciformes	
Picidae	
Colaptes auratus	common flicker
Dryocopus pileatus	pileated woodpecker
Melanerpes formicivorous	acorn woodpecker
Picoides pubescens	downy woodpecker
P. villosus	hairy woodpecker
P. nuttallii	Nuttal's woodpecker
Strigiformes	
Strigidae	
Bubo virginianus	great horned owl
Otus kennicottii	western screech owl

CONVERSION FACTORS

Quantity	To Convert from Metric Unit	To Customary Unit	Multiply Metric Unit By	To Convert to Metric Unit Multiply Customary Unit By
Length	millimetres (mm)	inches (in)	0.03937	25.4
	centimetres (cm) for snow depth	inches (in)	0.3937	2.54
	metres (m)	feet (ft)	3.2808	0.3048
	kilometres (km)	miles (mi)	0.62139	1.6093
Area	square millimetres (mm^2)	square inches (in^2)	0.00155	645.16
	square metres (m^2)	square feet (ft^2)	10.764	0.092903
	hectares (ha)	acres (ac)	2.4710	0.40469
	square kilometres (km^2)	square miles (mi^2)	0.3861	2.590
Volume	litres (L)	gallons (gal)	0.26417	3.7854
	megalitres	million gallons (10^6 gal)	0.26417	3.7854
	cubic metres (m^3)	cubic feet (ft^3)	35.315	0.028317
	cubic metres (m^3)	cubic yards (yd^3)	1.308	0.76455
	cubic dekametres (dam^3)	acre-feet (ac-ft)	0.8107	1.2335
Flow	cubic metres per second (m^3/s)	cubic feet per second (ft^3/s)	35.315	0.028317
	litres per minute (L/min)	gallons per minute (gal/min)	0.26417	3.7854
	litres per day (L/day)	gallons per day (gal/day)	0.26417	3.7854
	megalitres per day (ML/day)	million gallons per day (mgd)	0.26417	3.7854
	cubic dekametres per day (dam^3/day)	acre-feet per day (ac-ft/day)	0.8107	1.2335
Mass	kilograms (kg)	pounds (lb)	2.2046	0.45359
	megagrams (Mg)	tons (short, 2,000 lb)	1.1023	0.90718
Velocity	metres per second (m/s)	feet per second (ft/s)	3.2808	0.3048
Power	kilowatts (kW)	horsepower (hp)	1.3405	0.746
Pressure	kilopascals (kPa)	pounds per square inch (psi)	0.14505	6.8948
	kilopascals (kPa)	feet head of water	0.33456	2.989
Specific Capacity	litres per minute per metre drawdown	gallons per minute per foot drawdown	0.08052	12.419
Concentration	milligrams per litre (mg/L)	parts per million (ppm)	1.0	1.0
Electrical Conductivity	microsiemens per centimetre (uS/cm)	micromhos per centimetre	1.0	1.0
Temperature	degrees Celsius (°C)	degrees Fahrenheit (°F)	(1.8 × °C) + 32	(°F − 32)/1.8